S. HRG. 107–1008

WATER QUALITY IN LAKE ERIE

FIELD HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED SEVENTH CONGRESS

SECOND SESSION

ON

ANOXIA IN THE CENTRAL BASIN OF LAKE ERIE, AND THE IMPACT OF "DEAD ZONES" ON THE ECOLOGY OF THE GREAT LAKES REGION

AUGUST 5, 2002—CLEVELAND, OH

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ONE HUNDRED SEVENTH CONGRESS
SECOND SESSION

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WATER QUALITY IN LAKE ERIE

MONDAY, AUGUST 5, 2002

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Cleveland, Ohio.

The committee met, pursuant to notice, at 10:30 a.m. at the U.S. Coast Guard Moorings Club, 1055 East Ninth Street, Cleveland, Ohio, Hon. George V. Voinovich presiding.

Present: Senator Voinovich.

OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Senator VOINOVICH. Good morning. The meeting will please come to order.

First, and foremost, I'd like to thank all of you for taking time out of your busy schedules to participate in today's field hearing of the Senate Environment and Public Works Committee, to better understand recent changes in Lake Erie's ecosystem, particularly, the central basin.

Second, I'd like to thank Chairman Jim Jeffords for calling this hearing at my request. I'd like to thank Senator Jeffords' staff member, Catharine Ransom, who is with us today, and, of course, my member of my staff, Karen Bachman, for their cooperation and hard work in putting this hearing together this morning.

Looking at the witness list, I think we we're going to have a very informative discussion.

On Panel One, I'd like to welcome Dave Ullrich, Deputy Regional Administrator for Region 5 of the U.S. Environmental Protection Agency; and Gary Isbell of the Ohio Department of Natural Resources, Division of Wildlife.

Gary and I have known each other for years—when you were just starting out in the department—he had a little more hair on his head and I had a lot fewer gray hairs. We were up at that wonderful hatchery that the State of Ohio purchased in Castalia.

Gary, I want you to know at one time I said at a meeting of the Trout Clubs of Ohio that before I died, I wanted to catch a steelhead on a fly in Ohio waters. I'm ready to go to heaven, because we've done wonderful things. That program has really made a big difference. I think that hatchery has something to do with it.

On Panel Two, I'd like to welcome Dr. Dave Culver of Ohio State University; Dr. Bob Heath of Kent State University; Elaine Marsh, Lake Erie Board Member of Great Lakes United; and Gerald Matisoff of Case Western Reserve University; and then Dr. Jeff Reutter of the Ohio Sea Grant Program. Jeff and I have known

each other quite some time. I visited him up at Stone Lab on many occasions over the years.

I look forward to hearing your testimony and learning more about the current status of Ohio's Great Lake.

I'd like to take a little bit of time, some of you might be interested in hearing this, some might not. I just want you to know that I've had a love affair with the Great Lakes all of my life in terms of my public service. One of the greatest sources of comfort and satisfaction has been my work to help clean up and protect the environment, particularly Lake Erie.

Lake Erie's ecology has come a long way since I was in the State legislature. I was commenting to some of the members of the media that when I ran for the State legislature, the northern district of my boundary was Lake Erie, and I made it an issue in the campaign. It was a dying lake. It was suffering from eutrophication. We had the BBC in here, it was a cause all over the world. This great fresh water lake was in such terrible shape.

So as a State legislature, we made a commitment to try to stop the deterioration, and what I'd like to refer to as wage the "Second Battle of Lake Erie" to reclaim and restore, to the best of our ability, Ohio's Great Lake. We continued that fight throughout my career in the legislature, Commissioner, Mayor, Governor, and now Senator.

Seeing the effects of pollution on Lake Erie and the surrounding region, I knew firsthand in 1966 that something had to be done immediately, or it would be too late.

I recall a neighbor of ours warning us not to swim in Lake Erie because of the problems, to get shots, go to a doctor before going into Lake Erie. We might get some disease from swimming in the lake. That's how bad it was.

Today, we celebrate Lake Erie's improved water quality. It's been a long struggle to win the "Second Battle of Lake Erie." I think it's really important that we understand the battle continues today. It's almost like the battle against terrorism in the world. It's never going to end, because the threats are always there. We think we got things taken care of in Lake Erie, and all of a sudden new threats come on the scene that we've got to deal with. So it's something that's going to require vigilance. We never can take the water quality or the lake for granted.

I was glad to see the chart downstairs of the amount of reduction in phosphates going into the lake from municipal waste. My first resolution in the legislature was a $360 million dollar bond issue to help the State of Ohio help municipalities clean up municipal waste. Of course, we saw the great progress made in this area with the 75/25 program by the Federal Government. I can assure you, that if the Federal Government hadn't come through with 75 percent of that money, we wouldn't see the progress that we have seen in terms of reduction of phosphates into the lake or the improvement of our waste treatment facilities.

Of course, during that same period of time we had the problem of the threat of drilling for gas and oil, exploratory drilling, in the bed of Lake Erie. I'll never forget calling the Speaker of the House, Charles Curfos, in fact, going in to see him. We formed, almost overnight, the four–State legislative committee on Lake Erie. With-

in 2 weeks we got resolutions passed for four State legislatures of not to go forward with the exploratory drilling of that lake.

I've got to tell you something, the Governors were really excited. They were getting boats and helicopters, they were going to do the whole thing. It was a new venture for them.

Then I was very much involved with the Seven–State Legislative Committee on the environment where we all, on the legislative side, put together the EPA for our respective States. I was the "House Father" of our EPA and worked with the Department of Natural Resources, Sam Speck was also with me on that committee.

Then the environment wasn't getting enough attention, so we created a House Environment Committee. I became vice-chairman of that committee. Then I became County Commissioner, and one of the things we needed to face was the Department of Energy wanted to use the salt mines out here to store radioactive—the waste from nuclear power plants. We fought that off.

Then, also as Mayor, we sponsored that first big international hearing on zebra mussels. We were really getting choked air, because they were clogging the water intakes, and we tried to figure out what to do about that. All of the people predicting what would happen because of the zebra mussels.

I'm pleased that Governor Taft now is chairman of the Council of Great Lakes Governors. When I was Governor, we funded Ohio's share of the funding, $14 million. We have a $100-million endowment, the interest from which is used to do research work on the Great Lakes. Some of you now benefited from some of that research work.

Then the Lake Erie Commission was kind of like a dead horse, so we breathed new life in that, moved it up to Toledo, and got Jeb Bush involved in that. We created the Lake Erie Protection Fund. We get some money that could help do research on issues that impacted the lake.

Then, of course, the Lake Erie Quality Index, which I thought was very important. I'm trying to get that done, nationally, for the Great Lakes. We ought to have an index on all the Great Lakes, so we have a baseline number, then we know where we're going in the future.

The Governor, I understand, has put together an implementation plan, and I'm hoping that in 2003 we'll have another one, report in Ohio about how we're doing and what progress we're making. We have to continue to monitor constantly.

Then how did I luck out? I got to be on the Environment and Public Works Committee. I'll never forget the first day we had a hearing, it was hard for me to believe I was on the Environment and Public Works Committee which the Federal EPA testifies before. In 1971 Bill Ruckleshaus sent me out to Cheyenne, Wyoming to talk to Rocky Mountain legislators about not giving up their water and air on the altar of economic development. That was long ago.

I had the chance of working on the WRDA bill, the 2000 bill was my bill, and also that bill dealt with the largest restoration project ever undertaken in the world. That's the Everglades. I know some of you want to do the same thing on Lake Erie, so we get the same

kind of attention, here, as they do in the Everglades, and also the Chesapeake Bay area.

We were able to authorize a $100 million dollars for projects to restore the Great Lakes fishery and ecosystem. By the way, there's some comments that have come in your reports about the Army Corps of Engineers, whether the Army Corps of Engineers should be doing this work. The money for this comes out of WRDA, and Catharine knows, that one of the testimonies suggested we ought to separate the money out for environmental restoration and the other for typical Army Corps of Engineers. There didn't seem to be that much enthusiasm for that.

I want to point out is that because the Corps is doing it, that does not mean that that money for research isn't going to be going out to people, like yourselves, doing research. I want to make sure that is the need is taken care. I think that is some of the concerns that you have, that the Corps is overlooking.

The other thing that I've been working on since my first year, 1999, was the reauthorization of the State Revolving Loan Fund for the Clean Water Act Revolving Loan Fund. We are just underfunding that miserably. We need to increase that. We're just asking for $3 billion more a year for 5 years. The bill has been voted out of committee. I have a little problem with it because all of the local people in the National Governors' Association are opposed to it. Too many mandates are connected with it and very little money. But, hopefully, we're going to resolve those and be able to bring that bill to the floor this year.

The bottom line is the Federal Government is not spending enough money to deal with waste treatment in this country. It needs to be given a much greater priority. There's a group called WIN that says we're going to have to spend $57 billion in the next 5 years to deal with our waste treatment problems, and also problems in terms of safe drinking water. Big, big problems. They need to be addressed. In addition, we have two additional bills that we are co-sponsoring. One is the Great Lakes Ecology Protection Fund, which would help prevent the introduction of aquatic nuisance species in the Great Lakes by regulating vessels that enter the Great Lakes. Then the Great Lakes Legacy Act, which would authorize $250 million in grants to States to clean up contaminated areas, such as the Maumee, the Black River, Ashtabula, and Cuyahoga Rivers.

You all know that Lake Erie is a great natural asset. It's a major supply of drinking water, a recreational resource, a fishery, and a source for transportation. It has enormous, positive impact on the economy, environment, and the quality of life in our State, enormous. I have seen, firsthand, the tremendous impact Lake Erie's revival has had not only on the ecology of the lake, but also on Ohio's economy.

If you look back 40 years to the time when the lake was dying, and look what it is now, you can appreciate the impact that the lake has had on Ohio. We cannot let anything diminish or set us back in our efforts to maintain and improve Lake Erie's water quality. From the testimony submitted for today's hearing, I am very concerned that we may be on the edge of sliding back, rather than moving ahead.

That is why we're here today, to discuss increasingly and extensive oxygen depletion, anoxia, in Lake Erie's central basin. The existence of this "dead zone" phenomenon is deeply troubling. You know, anoxia over the long term could result in massive fish kills, toxic algae, and bad-tasting or bad-smelling water.

In order to better understand this occurrence in Lake Erie and determine what, if anything, can or should be done to prevent dead zones in the future, we have to conduct extensive research.

I look forward to hearing more about the research being conducted in Lake Erie, and its results thus far. I'd also like to hear from you today, about your opinion of the adequacy of funding to do the research on this phenomenon that we're confronted with. I'm pleased that the USEPA has taken this on very seriously and that you've got the Lake Guardian out here doing the research work and monitoring the progress, if any is being made.

I'd also like to thank Governor Taft. Recently, I wrote to him about my concern about dead zones in Lake Erie. Last week, I received a very, very informative response describing the State's efforts to address this new challenge, which I will make part of this hearing record.

I'm pleased, also, that the Lake Erie Protection Fund has provided some billion—not billion, too many days in Washington—this million and a half dollars for ten projects that directly assess issues related to oxygen depletion. I also have requested that a provision be included in WRDA 2002 to authorize the Army Corps to study and report on water quality, environmental quality problems throughout the waters of Lake Erie resulting from the formation of dead zones.

I notice that Admiral Silva is here today. Admiral, we're very happy to have you here. I had a chance to meet the Admiral several weeks ago, and with you on board we're looking forward to having a wonderful relationship with the Coast Guard.

And, again, I apologize for the long statement, but I thought some of you should get a little perspective about how long I've been working on this battle to save Lake Erie, and how, after all of this work, I don't want to see us go back at all, period. We've got to move forward.

So we are very, very fortunate to have with us David Ullrich, who is the Deputy Regional Administrator of Region 5, U.S. Environmental Protection Agency, and Gary.

I think I'll first call on Dr. Ullrich for his testimony.

STATEMENT OF DAVID A. ULLRICH, DEPUTY REGIONAL ADMINISTRATOR, REGION 5, U.S. ENVIRONMENTAL PROTECTION AGENCY, CHICAGO, ILLINOIS

Mr. ULLRICH. Good morning, Senator, and thank you very much. I'm very pleased to be here.

As you mentioned, I'm the Deputy Regional Administrator for EPA out of Chicago. I'm here on behalf of Tom Skinner, who is our regional administrator and head of our Great Lakes office as well. I thank the committee for giving me an opportunity to talk about the troubling changes that we are seeing in Lake Erie.

What I hope to do is present a summary of the current situation as we see it, and our response to what may be occurring in the

lake. I will address the committee's questions regarding why anoxia, or the low oxygen levels, is occurring, particularly, in the central basin of Lake Erie. The effects of anoxia on the lake's ecosystem, and solutions to prevent anoxia from occurring in the future.

I will also be submitting, for the record, the Lake Erie Lakewide Management Plan, the Lake Erie Supplemental Study on Trophic Status, and the Great Lakes Strategy. I will address these during my presentation.

As you mentioned, it was two to three——

Senator VOINOVICH. We'll also make them part of the record.

Mr. ULLRICH. Very good, thank you.

Senator VOINOVICH. And one of the things I would like to explain to our witnesses, if you could keep your testimony to within 5 minutes or so, I would be very, very grateful, so we can get everybody on. Thank you.

Mr. ULLRICH. I will do my best.

It was two to three decades ago that the U.S. and Canada spent, literally, billions of dollars to upgrade sewage treatment plants, ban phosphorus from detergents, and improve agricultural nutrient management practices, all of which helped bring Lake Erie back from the brink of disaster to what it is now, one of the greatest environmental successes today.

Instead of sitting here on the shores of Lake Erie in Cleveland, next to a dead lake, we now see the affects of a true environmental renaissance on the Lake Erie shore line. The fruits of this economic rebirth have been spurred by the cleanup and revitalization of the Cuyahoga River, and the lake itself.

Senator we appreciate all you've done to contribute to that. You've given Lake Erie back to its citizens with the attendant recreational and economic opportunities, not the least of which, is a billion dollar world-class walleye fishery.

To maintain this success, EPA monitors nutrient levels as part of our Great Lakes Office Annual Monitoring Program. Through this program, we started noticing troubling signs of change in Lake Erie in the 1990's. Total phosphorus measurements, always considered a good indicator of the health of the lake, started to increase after years of decrease. These results were supported by Canadian data. Perhaps more telling was the return of a very low oxygen level in a large area in the central basin of Lake Erie, an area which has been referred to as "the dead zone."

The appearance of anoxia in Lake Erie is not a new problem. It's something that EPA is quite familiar with, and which we have successfully addressed in the past. But there is a new twist to the problem this time around.

Our past experience identified external loadings of nutrients, particularly phosphorus, as the main reason for the existence of anoxic conditions in the lake. EPA, and others, created the models that set targets for reductions of phosphorus to alleviate the anoxic condition in the lake. Once we reached these targets, the lake responded accordingly. Our current data, however, does not indicate any significant increases in loading of phosphorus or other nutrients to Lake Erie from external sources. So something different seems to be taking place.

One might ask if we should be concerned about these changes. My answer to that is an emphatic, yes. We should be concerned because there are a number of possible large scale and, potentially, very costly impacts which may be due to the changes we are observing. These changes could include impacts on fish and wildlife, beach closures, impacts on drinking water quality, and impacts from exotic species.

So clearly there are ample reasons to justify our concerns regarding the changes in the Lake Erie ecosystem. But why is this happening now? What is different about the current situation, as compared to the past problems?

Many scientists suspect the zebra mussels and other exotic species are starting to reshape Lake Erie's ecosystem in ways which they have not fully fathomed. Others theorize that the lake can be suffering from the combined effects of increased temperatures and lower lake levels.

Whatever the reason, I am here today to assure this committee, and the public, that EPA is aware of the recurrence of this problem, that we are already taking steps to address many of the concerns raised in this hearing. I will elaborate on two of these steps. First, in response to our identification of rising levels of phosphorus in Lake Erie, the Great Lakes office is undertaking, with many others, a $2 million dollar Lake Erie Supplemental Study of the Trophic Status. You'll be hearing more about that, and we have a number of prominent scientists, including once from Ohio University, the Ohio State University, and Case Western Reserve University, among others.

I strongly feel that this study will help us identify, if not answer, many of the questions that the committee has raised, and will help guide our solutions.

The second major step being taken is what we refer to as the Lakewide Management Plan for Lake Erie, which looks at a wide range of things that need to be addressed, including this problem. It involves many state organizations of the U.S. and Canada, and we'll be working together on implementing those solutions for the problems, and particularly the ones we identify in connection with the increased phosphorus levels.

These two things together, the study and the Lakewide Management Plan, plus a recently developed Great Lakes Strategy, which covers the broader five Great Lakes area and developed by the U.S. side, are things that will work together, again, to help identify the problems, the causes of the problems, and implement the solutions.

With this study in place it will help us understand and develop these solutions that we need to develop. We need to have a full understanding of the relationship between the external phosphorus inputs and the anoxia problem. There is no indication, at this time, that the loadings have increased, but I might add, that that needs further investigation.

A likely part of any long-term solution to the anoxia problem is made to aggressively address and to limit the introduction of exotic species into the Great Lakes. If zebra mussels are identified as the root cause of the anoxic conditions in Lake Erie, we will need actions above and beyond what the scope of EPA can do to address

this problem and prevent future introductions that could cause even more severe problems in the Great Lakes.

You may be aware of the Asian Big Head Carp that is now threatening the lakes. This is a voracious bottom feeder that would further complicate the situation, and adversely effect the ecosystem. In conclusion, I want to reiterate that what is happening in Lake Erie is not new, but its root causes may be. We are aware of this problem, and we have mobilized the resources and expertise to help us determine what actions need to be taken to address this troubling situation. Again, I thank the committee, and you, Senator, personally, for giving us an opportunity to speak. I will do my best to answer any questions that may be presented later.

Thank you.

Senator VOINOVICH. Thank you.

Gary?

STATEMENT OF GARY L. ISBELL, EXECUTIVE ADMINISTRATOR, FISHERIES MANAGEMENT AND RESEARCH, OHIO DIVISION OF WILDLIFE, OHIO DEPARTMENT OF NATURAL RESOURCES, COLUMBUS, OHIO

Mr. ISBELL. Thank you for taking such an interest in the issue, and on behalf of Director Speck and those in the State of Ohio, I want to express appreciation for the committee's willingness to seek input on this serious issue.

One of the things that I want to point out, it was my hope that in our examination of this issue that people don't erroneously conclude that the lake is dead or that fishing out here is less than pretty spectacular. I know that. You know that, and I want to make sure that, from a fishery management standpoint, that people understand that the lake is still a very viable resource.

Senator VOINOVICH. Gary, I'm glad you brought that up. One of the reasons why I want to have this hearing is to clear the air on that. We have writers here that cover outdoors, and I want to make it clear that that's the case. So often what happens is that people say the lake is dead, and before you know it everybody gets down on it, and the psychology just goes in the other direction.

Mr. ISBELL. Thank you.

While many of the rampant problems of the 1960's and all the images of the burning Cuyahoga River are gone, there are some new challenges, as the first witness has talked about.

The problem that the anoxic zone in Lake Erie is not that it exists, but it's size, frequency, and duration are changing. The anoxic zone is a naturally occurring phenomenon, but can be a serious detriment to the ecosystem if it gets too large, thereby limiting the potential of the lake to produce the benefits we really enjoy.

The real problem about the anoxic zone is just when we thought we had it figured out and managed, it's behaving in ways that we don't fully understand. We are unsettled by the observation that the reduction in nutrient loading, brought about by pollution controls over the last 0 years, appear to be trumped by something mysterious. A leading hypothesis is that zebra mussels are at the heart of the mystery, perhaps recycling nutrients that contribute to the development of a larger anoxic zone. A couple comments I want to make about what should be done. First, we must be aware that

there may not be a reasonable cure or fix to this current problem. However, we think that the collaborative study sponsored by the USEPA is a step in the right direction. Levels of nutrients in the lake and their effects on microorganisms were monitored fairly comprehensively in the past, through a similar USEPA sponsored study.

However, recent monitoring has not been funded sufficiently to help us detect problems or to devise solutions. As a result, comprehensive phosphorus monitoring, for example, was discontinued in 1994 for a brief time. While sampling was resumed in 1996, it really hasn't been consistent from year to year, and coverage of the lake, in terms of time and space, is not sufficient for us to be able to determine cures.

A stronger and more robust monitoring effort, we think, is justified and fundamental to the development of sound management strategies for the lake. This is an effort that is appropriate for Federal funding and leadership. We must have a solid, long-term data about the basic features of the lake in order to detect problems and prescribe solutions.

Second, this mystery about the anoxic zone is yet, I think, another wake-up call about the seriousness of invasions of aquatic nuisance species, and you know I've been involved in that whole issue for a long time in the department. Each new invader brings with it a random box of mostly negative effects. Some of the effects are not so subtle, such as predator-prey interactions of sea lamprey that devastated fisheries in the last century.

Sea lamprey control in the Great Lakes, we think, is a success story, thanks to the congressional support of the Great Lakes Fishery Commission and those sea lamprey control measures. Although difficult, these types of effects, those predator-prey effects are much easier to control and to model than the ultimate effects of nutrient recycling on, perhaps, yellow perch off of Cleveland here.

It's been 12 years since the passage of the first comprehensive Federal law regarding aquatic nuisance species. Even so, each year there is still more alien species that find their way to the Great Lakes. This is biological pollution that has the potential to permanently devastate many of the lakes' beneficial uses. A legacy we should strive to leave is a solid Federal policy that shuts the door to future invasions of the Great Lakes.

Anoxic zone mystery is just another part of a larger, complicated set of issues. It's encouraging to us, at the State level, to see Congress taking an interest and being willing to act. We urge you to do so, quickly, by funding more comprehensive monitoring with the lake. Lake Erie, given its hydrology, can change very quickly. Quick action may avert some significant and lasting negative effects.

Also, we urge you to act with a response that is appropriately scaled to the size of the problem. This is a huge resource; therefore, investigations and solutions will not be cheap. Water quality programs, lamprey control measures, electric fish barriers, ballast water management systems may be very expensive. However, the billions of dollars of resource values that are generated in the Great Lakes are worth it.

Finally, we urge you to act comprehensively. The anoxic zone problem is not an isolated issue within the Great Lakes ecosystem. It is critical for the development of long-range solutions to address the influx of invasive species into our waters as well. Therefore, I would encourage Congress to support a re-authorization of the National Invasive Species Act, and work collaboratively in strengthening and monitoring the survey efforts necessary. With proper funding, numerous State and Federal and private entities should be utilized to partner in the effort to conserve and protect this resource.

Thanks again for the opportunity to provide input to the Committee on Environment and Public Works. Please feel free to call upon the State agencies for additional information or review of strategies that may evolve from your initiatives. Thank you.

Senator VOINOVICH. Thank you, Gary.

Thank you both for your testimony.

Mr. Ullrich, how much coordination goes on between the Army Corps of Engineers and the EPA on this specific problem?

Mr. ULLRICH. On this particular problem, we're really just beginning to work with the Corps of Engineers on this. We have an office in Chicago that focuses on activities there. It would be out of our Cincinnati office that has responsibility for the Great Lakes and Ohio River.

I think we're really, still, in the early stages on this particular issue. We've worked on lake level issues and contamination sediments very extensively, so we've got this network of working relationships there, but we're very much in the early stages on this specific issue. But I think we've got an effective working relationship that should form the basis of a good partnership on this effort.

Senator VOINOVICH. Do you think it needs a little bit of encouragement?

The reason, I keep observing, in a lot of Federal agencies where they have relationships with each other so often—you say the same thing on war on terrorism, at home agencies talking to each other. We don't seem to have enough of that going on.

What I might do is get hold of General Flowers and ask if he can talk to Administrator Whitman and see if we can get a memorandum put together that focuses all the resources that concentrate on this problem, so the left hand knows what the right hand is doing.

Mr. ULLRICH. That is always helpful, Senator. We recently signed a memorandum agreement on contaminated sediments in urban rivers, which could help the Cuyahoga, among others, but that kind of thing is always helpful. Again, it deals with people working with one another to try to break through the institutional barriers that are there. I have certainly found in the past that letters, like you suggest, can be very beneficial.

Senator VOINOVICH. The other thing that would be very helpful to me, is to get a summary of all of the funding sources, right now, that are going to this issue, and identify what they are and the prospect of looking at additional money for this kind of work.

For example, the Great Lakes Protection Fund has provided a million and a half dollars. That's basically dealing with what the phosphorus levels are, looking at this problem.

Has any of that money gone into dealing with the invasive species?

Mr. ULLRICH. There are separate funding from the Great Lakes Protection Fund, and also from our Great Lakes office, particularly this new electric barrier that's put in the sanitarian chip canal in Illinois to keep the big head carp out of that. But, yes, there has been funding that has been used.

Senator VOINOVICH. Do you want to tell me about that? All I know about it is somebody called me and said that there's a problem with this Asian carp, talking about electric barriers.

Where is it at, and how do the barriers work?

Mr. ULLRICH. Well, it's just southwest of Chicago, I think the closest smaller town there is Lamont.

It's basically a wire stretched across the Illinois Sanitarian Chip Canal that is basically the connection between the Great Lakes and the Mississippi River watershed through the Illinois River. In April, under the Corps of Engineer's leadership and Fish & Wildlife Service, USEPA and many others were involved, it's basically an electric current that is put through that portion of the river, or the Sanitarian Chip Canal, and it's basically designed to keep all of the fish species on the Lake Michigan side on that side, and on the Illinois River side on the other side.

Senator VOINOVICH. So it's an electronic wall that's aimed at all species?

Mr. ULLRICH. All species, correct.

Senator VOINOVICH. You want to keep the river species out of the lake?

Mr. ULLRICH. Correct.

Senator VOINOVICH. And vice versa? Actually, it's flowing in.

Mr. ULLRICH. Right. The early indications are that it looks like it's effective. I think there are some concerns about it's long-term viability, but something needed to be done immediately, because these big head carp, and there are other varieties as well, have been slowly working their way up the Mississippi and then the Illinois River.

Once they get into the Great Lakes, as much as we experience with both sea lampreys and zebra mussels, it's extraordinarily difficult to control it at that point, so keeping it out of the system, is really where a priority has to be put. So we are optimistic about this, but it's something that has to be watched very carefully.

Senator VOINOVICH. One of the things that many of us are concerned about is the zebra mussels, and now there's another mussel related to it.

Mr. ULLRICH. Quagga mussel.

Senator VOINOVICH. Yes, the quagga.

We talked about this a long time, there isn't any predator for them, I guess. We've done some studies on that.

Is there any way that we can get rid of the zebra mussels as we did with the lamprey?

Mr. ULLRICH. My understanding is that we haven't been very successful with that as of yet. Gary is probably more familiar with some of the work that's been done. I guess the round gobies do eat some of them.

Mr. ISBELL. We find zebra mussels and quagga mussels in the stomach of a lot of the fish in Lake Erie, even yellow perch, which is quite surprising, but not to the extent that they would really control their abundance in great numbers yet.

As far as physically removing them, other than in the water intakes and so forth, there doesn't seem to be any control measures there.

Senator VOINOVICH. There's nothing that anyone has come up with, either chemical or predator or anything of that sort, that would start?

Mr. ISBELL. To reduce their abundance, in general, in the lake, no. To reduce their abundance, maybe locally, I think gobies may, indeed, have effects on them. There are some control measures we're using, for instance, in our hatcheries and so forth, to make sure they're not spreading out, but not in a general sense out in the lake.

Senator VOINOVICH. Well, what worries me is that if the research were completed and that's the problem, what do you do about it?

Mr. ISBELL. That's why I mentioned in my text that it may, indeed, be something that we're aware of and if it effects things out there, there may not be much we can do, other than control the loading phosphorus, things that we do have control over.

Senator VOINOVICH. I would be interested in your recommendations, yours and anybody else here, in terms of the Invasive Species Act we talked about, re-authorization of that.

Also, you're—getting back to what I said earlier about funding in terms of its adequacy.

Mr. ISBELL. Let me talk about aquatic nuisance species. First, Dave mentioned the Sanitarian Chip Canal issue and the electric barrier issue, that is, indeed, one of the focal points of aquatic nuisance species, both leaving the Great Lakes and affecting the Mississippi drainage, as well as Mississippi aquatic nuisance species, such as the Asian Carp finding their ways into the Great Lakes.

That's an issue that is yet unresolved. The electric barrier, as David talked about, is a first measure. It was originally designed with gobies in mind, trying to keep gobies from coming to the Mississippi. But, obviously, it has a much broader use.

The other point, as you're well aware, is that everything that comes into the Great Lakes via ballast water, comes up the St. Lawrence, pretty much. We have that issue to deal with, ballast water. I think the National Invasive Species Act is an excellent instrument to address additional ballast water research, ballast water management systems, regulations and so forth, which has probably slowed the parade of aquatic nuisance species to the Great Lakes. Nowhere to the point where we feel comfortable about it.

Again, if we don't have the sort of constant monitoring out here, what's going on in these lower levels, such as the nutrient levels and microorganism levels, by the time you and I see a difference in our walleye and perch fishing, it's too late.

Senator VOINOVICH. Right.

Mr. ISBELL. That's what worries me.

Senator VOINOVICH. One of the things that you mentioned, also, was the issue of how valuable Lake Erie is to this region, and to

the country. I suspect that the Department of Natural Resources, or someone, has captured the economic impact of our Great Lake.

Mr. ISBELL. Yes.

Senator VOINOVICH. It would be very important to me if we get that information in one place, because if we're going to be arguing, as you can well imagine, there is competing needs in Washington. Everybody has got their own pet project, as I mentioned the Everglades, the money we're spending there and other places, and we need as much information as possible to say, look, this is a real problem, something needs to be done with it, and this is the impact that it has on the State and on the region. So that I've got some ammunition there to justify the expenditure of more money. I'm sure that's someplace.

Mr. ISBELL. Senator, if I know Jeff Reutter at all, he'll probably give you some numbers before we leave.

Senator VOINOVICH. His eyes are gleaming there.

Mr. ULLRICH. We do have data on that as well, Senator. I think the sport fishery, alone, on Lake Erie is estimated at well over a billion dollars.

Going back to your question on the invasive species, my concern is that it isn't being recognized for the magnitude of the problem that it is, and just getting some more visibility to it.

Invasive species are causing billions of dollars in this country to deal with. In the Great Lakes, alone, we're seeing about one new species a year introduced. The area that we're most concerned about, in the work that we've done, are these no ballast on board ships that aren't required to do the ballast water exchange out beyond the exclusive economic zone of 00 miles, but come in with no ballast on board, but have some live predators still in the ballast tanks. As water is exchanged, while it's going through the Great Lakes, we feel that that is the primary source of the new introduction of species.

We work very closely with the Coast Guard and Fish and Wildlife Service, both on the U.S. and Canadian side, to really pinpoint this. The real problem, right now, is effective treatment of the ballast water, and finding a way to deal with that is really where research is needed. EPA is doing some of that research, but much more is necessary.

So that's really—there are other vectors, but that no ballast on board situation is the one we're most concerned about and we're working closely with the Coast Guard.

Senator VOINOVICH. The Coast Guard is in charge of enforcement?

Mr. ULLRICH. Yes.

Senator VOINOVICH. But, again, you also need the cooperation of the countries that are bringing this stuff in?

Mr. ULLRICH. Yes, we do. But, again, the primary cooperation has to be with Canada, so we have a uniform set of standards that would be applied. A lot of work is being done with the International Maritime Organization. Again, trying to get an agreement across the entire globe on these things is very difficult. Because of the sensitivity of the Great Lakes, it's particularly important that we get these controls on because it may be creating situations like——

Senator VOINOVICH. Again, if you've got some more on that, I'd like to zero in on that.

One of the frustrating things I've had over the years, is all the organizations that deal with the Great Lakes and trying to keep track of them. It's just amazing. As you well know, once an organization is created it's very difficult to get rid of it.

I have one other question for you, Mr. Ullrich, and that is, in your testimony you briefly discussed the occurrence of type E botulism and avian botulism in Lake Erie in recent years.

What are type E botulism, avian botulism? How are they affecting the ecosystem? And why are they occurring, and what are we doing to stop it? And do these exotic species have any play in increased occurrence of this?

Mr. ULLRICH. What we're dealing with with this botulism is a bacteria that is particularly threatening to the avian community, the birds and the water fowl and the gulls. Again, this is something that does require more research, but there is a feeling that there may be some connection with the phosphorus and the zebra mussels. I'm going to leave this to the scientists ultimately to determine this.

But it's felt with the buildup of decaying matter on the bottom of the lake, and this being picked up through this zebra mussels, perhaps, and through the round gobies, what has been found, particularly, with some of the cormorants and loons that have died, and the red-breasted mergansers as well, that there have been some of these round gobies found in their guts where the botulism may well have come from that have killed these birds.

So, again, and maybe Gary has some more information on this, but it's felt that there may be a link between these. The die offs have increased recently, and it is an area of great concern, so there is a feeling that that link may exist. Again, it goes right back to the phosphorus zebra round gobie problem, which are the invasive species. At a minimum, we've got to keep new ones from getting in, and figure out, better, how to deal with the ones we have.

Senator VOINOVICH. Gary?

Mr. ISBELL. I think he's got it covered from that standpoint. Just to let you know that, geographically, it seems as though the problem has been east of here. We're not sticking our heads in the sand, we're out there sampling fish and following up on calls from anglers and so forth, and looking when there is dead fish and sending fish for testing.

We have not experienced serious botulism problems down this way, but since we don't know why exactly it's being caused, we're trying to look and see if it's going to occur. It has been quite serious for the recent year in Pennsylvania waters and New York waters, and so forth. Those folks are very, very concerned about it.

Senator VOINOVICH. Again, it's one of those mysteries?

Mr. ISBELL. It's a mystery. Like he said, there is some exotic species in the western basin, and with sheepshead, we saw lots and lots of sheepshead, and we collected some samples and sent those in, but it wasn't due to anything in the environment, like low oxygen or decaying materials or anything like that, so we are going to have to sort out what naturally occurs each year versus some of the systematic effects. We don't know that about botulism yet.

Senator VOINOVICH. You think possibly gobies might be——

Mr. CULVER. It has been true that down east from here when they open up animals that have died from botulism, they do find gobies in there. Whether that's cause and effect or just an association, has yet to be determined.

Senator VOINOVICH. Reminds me of the Everglades. There is one problem, there's another one, we clean it up, but they have some come exotic species that have invaded that, and unless they get those under control, they're in big trouble.

Senator VOINOVICH. Thank you very much. I appreciate you being here and we'll look forward to hearing on some of those things I asked about.

Mr. ULLRICH. Thank you, Senator.

Mr. ISBELL. Thank you, Senator.

Senator VOINOVICH. Our next panel is Dave A. Culver, Ph.D., Department of Evolution, Ecology, and Organismal Biology, Ohio State University. Robert T. Heath, Ph.D., professor and director of the Water Resources Research Institute, Department of Biological Sciences, Kent State University. Elaine Marsh, who is a board member of the Great Lakes United, Buffalo, New York. And Great Lakes United, I've worked with them over the years. Gerald Matisoff, Ph.D., professor and chairman Department of Geological Sciences, Case Western Reserve University. And Jeff Reutter, director of the Ohio Sea Grant College Program, F.T. Stone Laboratory, Center for Lake Erie Research, Great Lakes Aquatic Ecosystem Research Consortium in Columbus, Ohio.

Thank you very, very much for being here today. And I think we'll start off with Dr. Culver.

STATEMENT OF DAVID A. CULVER, PROFESSOR, DEPARTMENT OF EVOLUTION, ECOLOGY, AND ORGANISMAL BIOLOGY, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

Mr. CULVER. Thank you very much. I come here representing a very large group of researchers who are involved in the LaMP, involved in the EPA Supplemental Sampling Trophic Studies Project, Lake Erie Index Program, and many, many others activities.

What I would like to do is—actually, what I would like to do is present some information that shows some of the results of what we found. Probably, what I'll do very first thing is restore that overhead.

What I would like to show is the fact that as it's been discussed, the removal of phosphorus from Lake Erie in the 1970's and 1980's have been very effective in decreasing the amounts of algae. We have the western, central, and eastern basins represented on this graph. And you can see that although we have different groups of researchers and different methods and so forth, the general trend is down. Here is where my data comes up, starting from LaMP sampling, and these have been done by the Ohio Division of Wildlife, and the Canada Center for Inland Waters.

Senator VOINOVICH. What year is that again?

Mr. CULVER. 1995 was the first samples that we had.

Senator VOINOVICH. OK.

Mr. CULVER. And you can see we had 3 years there where we had fairly consistent low values of algae. And then, starting in

1998, we see one very high point from the western basin when we had a microcystis and toxic algobloom go on, I have not included that point in regression, but you can see the western basin has been getting back up to 1980's kinds of values. The central basin has also increased, and I don't have data yet on recent years for the eastern basin.

But this data, right here, are consistent with the EPA's phosphorus data, which suggests that starting about the same time, total phosphorus was going up. As we all observed before, when total phosphorus goes up, the algae responds to that and the increase in algae is going to be responsible for a faster consumption of oxygen in the deep water of Lake Erie. So there's the problem right there, and the fact that you can measure it with oxygen or you an measure it with algae, either one, clearly indicates we are seeing some changes that are regressive, they're going back toward higher algo concentrations like we had in the past.

I support what Gary Isbell said, it's absolutely just a gorgeous lake out there. We were just out there 2 weeks ago on the Lake Guardian, and it's just spectacular. But these datas clearly suggest that we're going in the wrong direction.

The other couple points that I want to make about this is that we have been measuring, in conjunction with our work, the amounts of phosphorus released by zebra mussels. And we're also concerned about the fact that quagga mussels are gradually replacing zebra mussels in the lake. In fact, in the eastern end of the lake there has always been lots of quagga mussels, once they became introduced, in the deepest waters, but they have also come into shallow waters now along the hard substrates.

They're out there, and we just sampled again around South Bass Island, and there is 10 times as many quagga mussels as there are zebra mussels around South Bass Island, so this is a huge change. In 1993 there was one quagga mussel for every 100 zebra mussels. Now there's one zebra mussel for every 10 quagga mussels, so that's a big change. We also find that quagga mussels, in our preliminary data, tend to release more phosphate and ammonia than zebra mussels. So there's one possible thing we're following up as part of the trophic study as a potential source for the extra phosphorus we're observing. But my final point is in terms of solving these problems, we're not going to get rid of quaggas. We're not going to get rid of zebras. I think what we're going to have to do is to work all the harder on combined sewer overflows, reduce discharge by agriculture, reduce discharge by cities and industrial programs, and that's going to be expensive. Those are the things we do have control over in terms of nutrient input into the lake, and we're getting extra from zebra mussels or what other source, the few things we do have control over require additional help.

Thank you.

Senator VOINOVICH. Dr. Heath?

STATEMENT OF ROBERT T. HEATH, PROFESSOR AND DIRECTOR OF THE WATER RESOURCES RESEARCH INSTITUTE, DEPARTMENT OF BIOLOGICAL SCIENCES, KENT STATE UNIVERSITY, KENT, OHIO

Mr. HEATH. Senator, you know how professors are, we can't clear our throat unless we have an overhead in our presentation.

Senator VOINOVICH. We don't have that much in Washington. I think we'd be better off if we had more.

Mr. HEATH. I'm going to talk about one particular point that we have been examining for the past several years, a point that is about half a mile south of the international boundary, due north of Huron, and is located at that point there. It is a point——

Senator VOINOVICH. South——

Mr. HEATH. So it's due north of Huron.

Senator VOINOVICH. Where is Kelly's at?

Mr. HEATH. Kelly's is this, and this is Pelee Island

Senator VOINOVICH. You know it well.

Mr. HEATH. One of the questions that we've asked is what is different this year. And what is, first of all, not different is that it becomes anoxic at this particular point. For the past several years, and years before that, we have seen that this particular station regularly becomes anoxic, so as it's been pointed out before, it's not the—it's not that the bottom waters are becoming anoxic, but rather that the region of anoxia has become so much further expanded.

We have also asked at this point what—we've followed the rate at which it has become anoxic and asked what is different at this point, and whether this point is representative of what is going on elsewhere or not. We don't know, but we would suggest that these are places that need to be examined.

First of all, we've seen that there is lower transparency. There is greater phytoplankton biomass. We've seen an increased photosynthesis, at this point. There is also a diminished phosphorus limitation of phytoplankton, which is an important issue if we want to control this. If we see this as a phosphorus problem, then it's a problem that can be contained and controlled, only if the phytoplankton are responsive to diminished phosphorus.

So we're seeing a diminished phosphorus limitation, and also seeing greater total phosphorus, and most of that that we have seen at this point is an increased dissolved organic phosphorus, which is phosphorus that is conditionally available to organisms, but is not necessarily immediately available to organisms. And, finally, we've seen larger bacteria at this point this year than we normally see, indicating that they be more active, there may be a greater activity in the base of the food web, or that their grazers are diminished. So it's important to keep in mind that this may not be simply a eutrophication problem akin to what we've had in the past. It can also be many—there are many other possible explanations for this.

How does this lead to anoxia? Just to step quickly through this, increased production at the base of the food web can lead to phytoplankton that are incompletely grazed and that, in turn, leads to oxygen depletion when they're decomposed in the bottom waters for naturally occurring bacteria.

How it is that we have this, you see it could be a food web problem, which, I believe, is where further research needs to be done. My colleagues, who I respect greatly, have focused exclusively on this being a phosphorus production problem, and we need to recognize that research needs to be done to examine all of the possibilities with it being, perhaps, a greater food web problem.

Senator VOINOVICH. You're saying it's a food——

Mr. HEATH. A problem with the food web. So if you have too many algae, it could be because something is causing overproduction, which is where the predominant hypotheses are. Phosphorus being recycled from zebra mussels, or it could also be an inadequate consumption problem, that there is something with the grazers, with the grazing food chains involved in an incomplete grazing of the phytoplankton.

What I believe we need is, first of all, that we need new ways of placing the current research into a more useful context. We have—every time that the problem occurs in the Great Lakes, as you know, we rush out and we do more research, yet that research is seldom parceled together and grouped together. We need to have ways of coordinating those activities. For example, in large models such as found in the Great Lakes Modeling Summit the focus on Lake Erie, which was an IJC publication 2 years ago.

Also, we need ways of incorporating continuous, comprehensive monitoring activities, such as is being done by the USEPA, that are at levels far expanded than what we have at the moment. Much of what we do is when there is a problem, then we go out and we begin to do something. We need to have some continuous, intensive monitoring to guard these Great Lakes.

And, finally, and I know that you have been one of the champions of the Great Lakes for a long time, the Great Lakes need to be valued as international treasures, and that issues besetting the Great Lakes need to be addressed in innovative, binational ecosystem monitoring, research and management programs. So I would say that we need, also, to incorporate our efforts with the Canadians.

Thank you very much, Senator.

Senator VOINOVICH. Thank you.

We are working with the Canadians on the issue of taking from the Great Lakes, and it's comforting to know that Sam Speck of Ohio is kind of coordinating that effort. I suspect in the next year or so, what is it called the Lake Erie annex, we'll be coming up with some Federal legislation to deal with that problem.

It's amazing all of these international agreements, if it wasn't for the WTO I don't think we would be involved in that. Up to that time the Governors, I thought, were doing a good job of handling the Great Lakes. And, of course, some of them said that it's in commerce and, therefore, we need to look at that aspect of it.

Never ends.

Elaine, I'm very glad to have you here today.

STATEMENT OF ELAINE MARSH, BOARD MEMBER, GREAT LAKES UNITED, BUFFALO, NEW YORK

Ms. MARSH. Thank you very much, Senator. I was on a conference call for my work with Great Lakes United last Tuesday,

and we were talking about what remains of the toxic problems in Lake Erie and what needs to be done. And we were talking, specifically, about you, Senator, and the work of the Great Lakes Legacy Act that you are proposing, and we were talking about things like Senate Bill 961 and how important your work has been.

On the conference call someone said, we simply have to find a way to thank Senator Voinovich for all of his hard work, so I would like to take this opportunity, Senator, to thank you for that. We really appreciate it.

Senator VOINOVICH. Thank you.

Ms. MARSH. I'm here as Lake Erie Regional Representative on the Board of Great Lakes United, an international not-for-profit coalition dedicated to protecting and restoring the Great Lakes–St. Lawrence River ecosystem. Great Lakes United's 150 member groups represent tens of thousands of people from eight Great Lakes States and the Provinces of Ontario and Quebec.

We get most of our information from the other people on this panel related to the scientific causes of the problems, and our research certainly agrees that this is a very complicated problem. That it involves nutrients from combined sewer and sanitary sewer overflows. That it is related to nuisance and exotic species, and that it's also related to the global warming issues. So I would like to focus on a couple of issues that we believe need to be corrected.

One of those is the issue of sewage infrastructure. As you are well aware, it's a huge and expensive problem and one that will not be solved unless there are some funds available from the Federal Government. The city of Toledo is talking about $400 million dollars. The city of Akron $370 million dollars. There is no way, even with the best of intentions and greatest plans that both of these cities have, that they can do that. Ten times the rate of paying for sewage treatment which some cities claim would be necessary in order to meet the 15-year requirement of the CSO regulations, is not a possibility.

So this is just very, very important, and, in addition to the anexia, there are other aspects of the problems related to incomplete sewage treatment from combined sewer and sanitary overflows. One of those is, beach closings. Beach closings are more than a problem of phosphorus loadings, they are a problem for recreational use, which is, in turn, a quality of life and economic problem.

So we're very concerned about that and we're very supportive of efforts to get new sewage treatment infrastructure spending. We believe that the dead zone in Lake Erie and the increased number of beach closings around the lake are strong indicators that untreated waste inputs are on their way to becoming a health crisis for Lake Erie communities.

Great Lakes citizens are advocating immediate end of combined sewer overflows, and also we want mandatory notification of daily bacteria counts at public beaches. We believe that this would increase awareness, as well as safety for the region's populations.

We certainly support the control of exotic species through ballast water and other shipping issues.

Finally, in terms of protecting Great Lakes levels from the potential future effects of climate change, we believe that we need to

greatly reduce CO^2 emissions from two major sources, coal fire power plants and automobile emissions. Great Lakes citizen groups are advocating for mandatory cap of CO^2 emissions from power and transportation sectors that guarantee reductions of CO^2 emissions by 60 percent by 2020.

We also strongly support the research on Lake Erie under the binational Lakewide Management Plan, headed by EPA's Great Lakes National Program Office and Environment Canada's Great Lakes program. The LaMP mechanism, as mentioned by others, set up under the Great Lakes Water Quality Agreement, includes government and public participation that are so critical to successfully dealing with the complex set of events that we're dealing with in Lake Erie.

We also ask that you and the committee support restored funding of the U.S. Fish and Wildlife Service Lower Lakes program to enhance monitoring and oversight of Lake Erie and Lake Ontario.

Senator VOINOVICH. Thank you.

Dr. Matisoff?

STATEMENT OF GERALD MATISOFF, PROFESSOR AND CHAIR, DEPARTMENT OF GEOLOGICAL SCIENCES, CASE WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO

Mr. MATISOFF. I've been asked to provide technical expertise, in part, because of my role as a project director on EPA-funded grant Lake Erie Trophic Status, which began this summer. Before proceeding, I would like to take this opportunity to thank EPA personnel and the Great Lakes National Program Office for making this project possible. It is only through their recognition and involvement and rapid response to mobilize the necessary resources that enabled us to conduct this study.

My name is Gerald Matisoff, and I'm professor and Chair of the Department of Geological Sciences at Case Western Reserve University. I've also served as editor of the Journal of Great Lakes Research for the past 5 years, and have been active in Great Lakes research since the 1970's. I've provided a CV with my written testimony, which includes my publications pertinent to Lake Erie.

In my written testimony I have provided brief explanations about why anoxia is occurring in the central basin of Lake Erie, about the effects of anoxia on the Lake Erie ecosystem, and about solutions to prevent anoxia from occurring in the future.

I'll not reiterate those comments here, instead, I'd like to take the remainder of my time to familiarize you with the nature of our EPA-funded research on Lake Erie this summer. Some of the other panel participants are actively involved in the project.

Perhaps the best way to explain the nature of the research is within the framework of a Lake Erie ecosystem model. If you consider the projected figure, entitled Lake Erie Ecological Model Lien, this figure is not in my written testimony because it is not my work, but rather that of two colleagues of mine in the Biology Department at CWRU. However, it illustrates, quite nicely, the complex nature of the ecosystem and the problems that we're trying to address.

What I would like to point out are the following four points. First, note the black box with phosphorus and sunlight as input

materials, and fish as the output product. In this conception, the entire system is driven phosphorus input to the lake. In order to better understand this system, it is necessary to better understand and quantify all of the phosphorus sources, including point sources, tributarial loadings, and internal cycling within the lake itself.

Second, the model does not consider spatial or temporal variability. Clearly, the distribution of phosphorus varies daily on a weather, seasonal, and annual basis. Similarly, various ecosystem components are known to have patchy distributions, which are small relative to the size of a very large lake.

Also, it is well known that there are differences between the three basins of the lake between the near shore and the off shore. These various spatial and temporal variations are not regularly measured and are not well understood. Third, zebra mussels have completely changed the ecosystem. The lake is not at equilibrium, so it is not known what equilibrium mussel population will eventually be. Zebra and quagga mussels are not the only non-indigenous species. To date, there are more 161 known exotic species and some, but not all of them, have caused significant ecological havoc. The ecosystem changes will continue to occur until the regular invasion of the Great Lakes by non-indigenous species is stopped.

Finally, please note that this model is not linked to lake chemistry, water exchange, dissolved oxygen, or the physical flow of water nutrients or contaminants. A better understanding of those linkages will be needed to better describe the dynamics of the system.

Note that although the model appears to be a very simplified description of the lake, and in some ways it is, there are ,942 parameters buried in there. They represent processes, and those processes are what the researchers on the grant seek to understand. Our approach is to apply as many tools and techniques as possible in order to collect the broad spectrum of data need to determine its relationship between widely different pieces of the ecosystem.

As a result, we developed a project that included investigators to study as many pieces of the problem as possible. In our project, we ended up with 27 investigators from 18 institutions. Project is primarily field-based and was designed to collect samples and data using EPA's RV Lake Guardian and the Canadian Coast Guard Vessel Limnos. The sampling effort includes the measurement of water-related attributes, sediment-related attributes, an inventory of the organisms within the water column and at the bottom of the lake, including zebra mussels, to derive and extrapolate energy processing and nutrient transfer from zebra mussels to round gobies, and to quantify particle transport processes and nutrient sources among compartments. There were 11 specific objectives itemized in my written testimony and which are given in the grant proposal. The field sampling is to continue throughout the summer. To date, sampling trips aboard the RV Lake Guardian occurred in June and July. Since the research efforts have been focused on data collection, no attempt has yet been made to fully coordinate the data and/or interpret it. However, we are planning group meetings in mid–November and next March and next June to compile and interpret the data.

We hope to have answers to many of your committee's and EPA's questions. But while we hope to have those answers, it's important to understand that this one time field-based sampling survey will not, necessarily, provide all of the answers to the complex ecosystem problems that are previously described.

Senator VOINOVICH. Thank you.

Jeff?

STATEMENT OF JEFFREY M. REUTTER, DIRECTOR, OHIO SEA GRANT COLLEGE PROGRAM, FRANZ THEODORE STONE LABORATORY, CENTER FOR LAKE ERIE AREA RESEARCH, GREAT LAKES AQUATIC ECOSYSTEM RESEARCH CONSORTIUM, COLUMBUS, OHIO

Mr. REUTTER. Thank you, Senator. It's always a pleasure to see you, and I thank you very much for your leadership of this and hosting this. I also want to compliment the other speakers, and it is indeed a pleasure to work with all of the scientists that have presented today. They are outstanding scientists. It's also been a pleasure to work with your staff here in Ohio and in Washington.

The take-home message from my testimony is simple. Due in part to changes brought about by invading species, zebra and quagga mussels and reduced water levels, I'm concerned that Lake Erie is headed back to the condition of the, quote, dead lake years in the 1960's and early 1970's. We must determine if that is, indeed, accurate. And if accurate, we must identify corrective actions.

Finally, we must recognize that Lake Erie may be a model for many other bodies of water in this country, and we must transfer the knowledge we gain from this lake to prevent the same thing from occurring in other locations of the country.

Lake Erie is the southernmost, the shallowest, and the warmest of the Great Lakes. The other Great Lakes are all in excess of 750 feet deep. The deepest point in Lake Erie is 212 feet, making it the smallest by volume. The watersheds around the other four Great Lakes are all dominated by forest ecosystems. The watershed around Lake Erie is dominated by agricultural and an urban ecosystem. As a result, Lake Erie receives more sediment and more nutrients than the other Great Lakes.

Now, if the lake is the southernmost, the shallowest, the warmest, and the most nutrient enriched, it should be the most productive. It is. In fact, we often produce more fish for human consumption from Lake Erie than from the other four Great Lakes combined, but it is possible to have too much of a good thing.

A little over 30 years ago the Cuyahoga River burned, and Lake Erie was labeled a dead lake. Nothing could have been further from the truth. In reality, the lake was still alive. We had put too nutrients into the lake from sewage and agricultural runoff. These nutrients, especially phosphorus, allowed too much algae to grow, and that alga used up all the oxygen in the water and when it died, it sank to the bottom and was decomposed by bacteria.

Scientists divide the lake into three basins. The western basin is the area west of Sandusky, and has an average depth of only 24 feet. The eastern basin is the area east of Erie, Pennsylvania and contains the deepest points in the lake. The central basin is the large area between Sandusky and Erie, and the average depth in

that basin is between 60 and 80 feet, and it's also very flat. Unfortunately, it is that shape that causes this basin to become the home of the dead zone.

Lake Erie stratifies, in the spring, with a warm layer on top and a cold layer on the bottom. The line of rapid temperature change between these layers is referred to as the thermocline. These layers break up in the fall when the surface layer cools to the temperature of the bottom layer. The thermocline usually forms around 45 to 55 feet. This means that the western basin is too shallow to have a thermocline, except on rare occasions. The eastern basin will have a thermocline and there will be a lot of water below the thermocline in that cold bottom layer. The central basin will have a thermocline, but there will be a very thin layer of cold water beneath it.

At the time the thermocline forms there is plenty of dissolved oxygen in the bottom layer. However, due to its depth, there is no way to add oxygen to the cold bottom layer until the thermocline disappears in the fall.

Throughout the summer, the oxygen that was present when the thermocline formed, is used by organisms living in the area, including the bacteria, bacteria that are decomposing the algae. If large amounts of algae are present, then large amounts of oxygen will be required for the decomposition process. Therefore, if we could reduce the amount of algae, we could reduce the amount of oxygen required to decompose it.

Because the western basin seldom has a thermocline, this is seldom a problem there. And because the eastern basin is so deep, there is a large reservoir of oxygen in the bottom layer, enough to last until the thermocline disappears in the fall. The central basin, however, does not have a large reservoir of water or oxygen in the bottom layer because the basin is not deep enough. As a result, loss of oxygen or anoxia can be a serious problem in the bottom waters of the central basin.

Areas of anoxia were first observed as early as 1930. And by the 1960's and 1970's, as much 90 percent of the bottom layer of the central basin was becoming anoxic each year. This is why the lake was labeled a "dead lake." To reduce the amount of algae in the lake we needed to reduce the amount of limiting nutrient. By limiting nutrient, I mean the essential nutrient that is in the shortest supply. In fresh water this is often phosphorus.

Our models told us that in order to keep dissolved oxygen in the central basin, we needed to reduce the annual loading of phosphorus to 11,000 metric tons. This was accomplished and the recovery of the lake has been truly remarkable. That's the history. That got us up to the late 1980's.

Then we've seen unpredicted results since that time. On October 15th, 1988 we found the first zebra mussel in Lake Erie. Sea Grant initiated a research project to document the expansion, and 1 year later the densities in the western basin had reached 30,000 per square meter. Our research indicated that these mussels changed the way phosphorus cycles through the system.

Beginning in the mid 1990's, USEPA Great Lakes National Program Office observed a trend of increasing phosphorus levels in Lake Erie. We shared our observations of unexplained problems in

Lake Erie with the GLNPO scientists, and they asked that we bring together a group of Lake Erie experts for a meeting in their Chicago offices in December of 2001 to discuss the problems that we were observing, and to strategize about solutions.

As a result of this meeting, GLNPO is currently funding a one-year project, which Dr. Matisoff is leading, to better understand the dissolved oxygen problem. And I know that Paul Horviton and Glenn Warren were very much involved with that.

That rapid response was really pleasing to see a large Federal agency really turnaround a large project within very few months, and to see a group of scientists, again, led by Dr. Matisoff, I think there are about 25 scientists involved with that, to come together and address a problem that quickly.

I believe the oxygen problem is real and that it's growing. I believe its caused by excess phosphorus and reduced water levels, but I also believe that zebra and quagga mussels are having a significant impact. And more phosphorus means more algae and more zebra mussels, and because of zebra mussels, Lake Erie may not be able to tolerate the large amounts of phosphorus that it did in the past. Finally, with regard to climate change, we should mention that because it's also exacerbating the dead zone problem in Lake Erie. Since 1997, the water level has gone down by three to four feet. This reduction comes primarily from the cold bottom layer. Therefore, as the water level goes down, the volume of this layer is reduced, the oxygen reservoir is reduced, and we have a greater chance of having an oxygen problem.

As for the current year, I fear this could be a very bad year. We had a very wet spring. This means we probably received large loadings of phosphorus from agricultural runoff and from sewage treatment plants. Because many of our systems still have combined storm and sanitary sewers, allowing untreated sewage and the nutrients it carries to enter the lake.

I'm really pleased with your supportive efforts to try to eliminate that problem and resolve the sewage treatment problem, but we still have agricultural runoff and we still have the zebra mussels to deal with. I have some thoughts and recommendations, but I think I'll hold those for the discussion. And I thank you for bringing this whole group together.

Senator VOINOVICH. Thank you very much.

The quagga mussels were exotic species that were brought in by the ballast, too. Were they here before the zebra mussel?

Mr. CULVER. They came later, and they were brought in with the ballast water.

Senator VOINOVICH. They're rapidly taking over the zebra mussels?

Mr. CULVER. Yes. We don't exactly understand why that is the case. We anticipate that it's associated with faster grazing or faster growth. There is some research now going on.

Mr. REUTTER. There is much more research on zebra mussels than quagga mussels. There are also about five additional mussel species that could be introduced into the lake at any time.

Senator VOINOVICH. So we don't have enough research—there is no leveling off, it doesn't reach a future point where——

Mr. CULVER. Actually, it works a different way, because initially we felt there would be a leveling off because the zebra mussels were associated primarily with hard substrates, and they didn't live or grow as well on sandy or muddy substrates. Gradually those areas have been covered with mats of them, which make their own substrate. And then there are quagga mussels that live very well in the soft substrate, which they did in the eastern basin when they first came in.

It's hard for us to predict exactly how will eventually be covered. One of the things this has been shown, is that unlike many times when a species is introduced wherein you have just a few specimens which form the founding population, very low genetic diversity, very slow adaptation to new conditions, zebra mussels came in with huge founding population, great genetic diversity, and people were saying they could never live very far south of here. And, of course, as everyone knows, it's living down in Texas, very nicely in Texas, because of that great genetic diversity. I'm anticipating the quagga will follow the same.

Senator VOINOVICH. What other parts of the world have the zebra mussels?

Mr. CULVER. The only place that I'm familiar with are Europe. They originally came from eastern Europe and moved into western Europe about 300 years ago when they built a rather extensive canal system, and that allowed the zebra mussels to move through. And then there's some suggestion that the improvement of water quality of the harbors in Europe has helped as well. These are areas where low salt conditions and all of these non-indigenous species can survive in the harbor areas where the ships may pull in their ballast water.

Senator VOINOVICH. Have any of the Europeans tried to do anything about it, any efforts, internationally, to deal with the problem?

Mr. CULVER. They were not very interested in zebra mussels. They'd always thought everybody had them. And with major research that's been done over here has stimulated a lot of research in Europe. Ireland has just recently received zebra mussels, and they weren't happy with that either. Boats that were coming on ferries, pleasure boats that were coming on ferries, from England over to Ireland were responsible, in part, for introducing the zebra mussels into the rivers and lakes of Ireland. That was happening in the late 1990's.

Senator VOINOVICH. So we can't learn from anyone else's experience, we're the genesis of the research?

Mr. CULVER. In large part that's true, but we're the only one with a Lake Erie.

Mr. REUTTER. When the zebra mussels first came in, we did a great deal of looking through the literature what was learned in other countries. One thing that we learned is zebra mussels were going to be able reproduce when they are three or 4 years old. In Lake Erie they are reproducing at 11 months old. Said that they'd be able to lay 50,000 eggs, in Lake Erie they lay one million eggs. Said that the larvae when they hatch would be able to be suspended within the water column for 11 days before they settle.

They can scatter very far in 11 days in the water columns. In Lake Erie they can stay suspended for 33 days.

Essentially, what we're seeing is that there is no place in the world that has the kind of densities that we have. This is zebra mussel heaven.

Senator VOINOVICH. Those were some of the observations early on. Some said, ultimately, that will level off and that hasn't been the case, and the quagga has added to that.

Mr. REUTTER. We have done so much more work on zebra mussels. It's a real mistake to assume they behave the same.

Senator VOINOVICH. They're a different species all together—not all together but——

Mr. CULVER. Same genus, different species. The quagga has clearly been able to push the zebra mussels out. What that means for the long term is hard to say.

Senator VOINOVICH. The theory is that they're what, they excrete more phosphorus, is that it?

Mr. CULVER. It's possible that they're producing a larger number of larvae, and larvae are sticking to established zebra mussels and covering them up, or they're growing faster or they're competing for food at the bottom. And so if the quagga mussel is able to suck in more of the water faster and extract algae so that the zebra mussels that are there are receiving primarily water that's already been cleared of its food supply, then the zebra mussels will not grow as fast, will not produce as many eggs and so forth.

But I've been amazed by how rapidly that change has occurred, in 9 years to go from 1 in hundred to 10 to 1 is just amazing.

Senator VOINOVICH. Dr. Matisoff, you're coordinating—somebody mentioned, the issue of does the left hand know what the right hand is doing in terms of all of this research.

That's one of the questions I have, does anybody really keep track of this in one place that knows what everybody is doing, so that we're utilizing our research money in the most effective way?

Mr. MATISOFF. Not on a daily basis certainly, but we are planning a meeting in November in which to share everybody's data and try and see if we can, in fact, use the data to help us understand and answer the broader questions.

Senator VOINOVICH. You have 27 people from 18 institutions that are working on this?

Mr. MATISOFF. That's correct, so we'll get the——

Senator VOINOVICH. Pardon me—who determined who the 27 were?

Mr. MATISOFF. We knew pretty much who did what kinds of research, so when we needed phytoplankton people, I called Dave Culver, and when I needed bacteria people I asked Bob Heath—and he turned me down, but so the answer to the question is we know who does what kinds of research and we called around. And I have a Canadian counterpart who did the same with the Canadian institutions. So we assembled a team, and there were many people who called—it was posted on a web page and they gave us a ring after they found out about it. We tried to work them into the project.

Senator VOINOVICH. You're coordinating this with the Canadians?

Mr. MATISOFF. Yes.

Senator VOINOVICH. And so the report that finally comes out next year will be applicable, and both governments will be benefiting from this?

Mr. MATISOFF. That's correct. We hope to get everybody together three times over the next year, to work assembling the data.

Mr. CULVER. It should also be pointed out, there are a large number of Canadian researcher vessels that are providing this kind of support. They're conducting this research project in the same way that the USEPA Lake Guardian is doing.

Senator VOINOVICH. It's a real coordinated effort, that's good.

Miss Marsh, are you doing what you can to lobby Washington to try and get more money for sewage treatment facilities?

Ms. MARSH. Yes, we are, Senator, but we need support. We'd be very happy to work with you to coordinate that, in whatever way we can.

Senator VOINOVICH. One of the frustrating things, from what I've heard, and correct me if I'm wrong, is that after all of the research, we may conclude there isn't much we can do about quagga or zebra mussels, that the only alternative we have is do a better job with sewage treatment and dealing with the problems of combined sewer overflows and agricultural runoff, and you mentioned, also, some industrial problems that we could be having, is that correct?

Ms. MARSH. Yes. And we also agree climate change is a factor and CO^2 emissions should be reduced in order to alleviate further effects.

Senator VOINOVICH. Jeff, you talked about the fact that you got lower water levels.

This will be my 23d year to go up to the Islands in my, now, very old boat. It's very interesting that I was out with Admiral Silva doing some public service announcements. One of them was with the Coast Guard. And the day before they were going to shoot the commercial on boater safety, I was told by the man that ran the marina I had gasoline in my bulk, in our boat there. I was saying afterwards to the admiral, thank God the camera couldn't smell, or you would have had to go to another boat.

But, anyhow, I've seen a lot over that period of time, and, you know, it's going to be difficult if that's the problem and we can't do anything about the other. I think that, somehow, we're going to have to capture that so people understand that that may be the only way we can do it; therefore, it becomes more important that we deal with that problem.

Getting back to my point about water levels, I've been going back and forth and I've seen the water levels going up and down, and there were times, early on, when I was in the legislature, they wanted me to turn on—have them turn off the spigots so we weren't getting so much water, because the levels were so high, and it wasn't too many years ago that they redid the docks and raised them up. Now they're down. And I wish I had brought some property on Cedar Point Road over by Cedar Point. Everybody was selling their houses, it looked like the water was just going to come over and invade them. Gary, you remember that, too, I think.

And, of course, now the water levels are down. The issue is—that's the debate we have in Congress about what impact does

global warming have on these water levels. But you genuinely feel that the scientists here if you had another three feet of water that it would be much different in terms of the problems that we're seeing here with this anoxic situation?

Mr. CULVER. Really the hypolimnion loses out. Because we have the same wind stress and everything else that mixes water down, so the hypolimnion tends to be thinner when the water level is low. That's where we lose out under those circumstances, that's correct.

Mr. HEATH. I was going to say part of the problem, though, is the water is warmer this year. As the lake becomes shallower, then the bottom waters will be warmer, so while there would be less—there would be a greater—the bottom waters would be warmer, that would stimulate the activities of the bacteria in decomposing the organic materials at the bottom. So it's hard to say whether we would have larger areas, or not.

Also, the problem with looking at this as a zebra mussel problem is that that would be highly ironic, because the one way in which you can get rid of zebra mussels on the bottom is to have large regions of anoxia. Zebra mussels are not tolerant to anoxic conditions. They require oxygen as well. I think we need to examine these areas and to look at our research and our hypotheses more broadly, than to simply focus on it as a zebra mussel issue.

Senator VOINOVICH. It would be interesting, just to say, if we've had warmer water and shallower water, then what impact would that have on this increase on phosphorus in the lake, and compare that with what you think you're getting from the quagga and the zebra mussels.

Mr. REUTTER. Those things really have to be looked at, Senator. If we reduce the thickness of that bottom layer, there is less oxygen available. In the sediments we're probably going to have the same demand for oxygen. We'll use up what is there more quickly. We'll see the anoxic problem occur sooner. It will last longer. If the temperature continues to go up, for every 10 degree increase in temperature, the rate of chemical reaction is double, so not only will we have a greater demand for oxygen, the rate at which we use it will also be increased. All of those things are working against us right now.

There is an old adage we used to say when we had the high water levels starting back in the 1972, 1973 area, we said that dilution of the solution to the water pollution. We are going exactly opposite of that.

Senator VOINOVICH. Colder waters, warmer waters, how does that all fit together?

I was interested in Professor Heath, he talked about that area I'm familiar with, and that's not the central basin, it's the western. Wouldn't that be considered the western basin?

Mr. HEATH. We would consider it right on the edge. Normally we'll note that as the Sandusky subbasin, which is sort of the gateway to the central basin.

As Dr. Matisoff mentioned, a lot of the assumptions in lake research have been that if we look at the nearshore stations, they will be very similar to off shore stations, but that's not the case.

Senator VOINOVICH. What is the water depth out there?

Mr. HEATH. Fourteen meters.

Senator VOINOVICH. You talked about the issue of coordination, do you think that, from your perspective, we need to do a much better job, or a better job, or a much better job in terms of coordination?

Mr. HEATH. I think we need to have a watershed coordination plan in place, recognizing that the Great Lakes watersheds are in both nations, in the United States and Canada, and we do not, in my opinion, do a good job of that, despite the valiant efforts of the Council of Great Lakes Research Managers and International Joint Commission. We do not have a continuous, ongoing data repository, nor do we have an annual meeting, that Dr. Matisoff mentioned, to include Canadians. Senator Voinovich. How can we improve that?

Mr. HEATH. Well, I think we can improve that by doing just that, perhaps, organizing meetings through the International Joint Commission and the Council of Great Lakes Research Managers, or by having web and Internet based data repositories.

Senator VOINOVICH. Who would be the one that would put that together?

Mr. HEATH. Well, hopefully—I guess, hopefully us.

I don't have a ready answer for that. I would hope that that would go through the International Joint Commission.

Senator VOINOVICH. I sure would be interested in your thoughts on it. I mean, I think that's a big deal.

Mr. REUTTER. I think we could make that happen, Senator. I'm the past chair of the Council. David Ullrich is the chair of the U.S. chair of the Water Quality Board. I think we could make that kind of thing happen.

Senator VOINOVICH. I'd like your thoughts and consensus. Maybe David, you, and Jeff could put together a recommendation, memorandum, or something to me, that I could share with the committee and with the Federal agencies, see if we can't move this along.

I know I just had breakfast recently with the new Canadian ambassador to the United States. We discovered that we knew each other in different capacities. He's very concerned as I am about all of the organizations, accessing all of our resources and working as closely as we can with each other in some of these areas.

The problem today is getting the resources, and you want to make darn sure that you get them, you're using them as efficiently as you can.

I'm going to tell you, switching the subject, to getting money for sewage treatment, with the Federal budget today, as it is, and all of the competing demands for the dollars, to get more money for just, for the revolving, you know, the SRF, it's going to be difficult. We need about $3 billion, at least. We get about a $1,350,000,000. A few years ago I worked with Senator Smith and some others, and we were able to increase that. And also some grants, grant program, very modest 2-year grant program, a billion and a half dollars, and you couldn't do the grant program unless you fully funded the loan program. They didn't do it.

So it's going to take an enormous amount of lobbying on the part of a lot of responsible organizations to get Congress to face up to the fact that we need to move forward and do something in this area.

So I just—you know, one of the things that the public doesn't know is that we have gone from a situation where we had a $313 billion dollar surplus for 002, we're going to probably borrow $340 billion dollars for 2002 just to run the government. That is all of the Social Security surplus, plus borrowing equivalent to about $340 billion, despite of what OMB says, we're probably going to have to borrow $400 billion dollars for 002. So everything that we're doing, it's all borrowed money.

In the context of that, we've got to try to make some hard choices and prioritize. The problem is that everybody wants to do everything. You can't if we're going to turn this economy around and get it moving. Then all of us have to be concerned, because looking down the road, what are we going to have left when the baby boomers hit Medicare, Medicaid, Social Security, there won't be any money for any domestic issues, even our national defense, at the rate we're going.

We've got to make some tough decisions and put some money into some of these areas. You know that the municipalities can't handle it. The rate increases, I don't even want to tell you how much we increased rates when I was mayor. That's a military secret. It was a hell of a lot of money.

Ms. MARSH. Senator, I also think that there is insufficient public understanding of the problem of combined sewer overflows. We really are just beginning to understand their effects on health, their effects on the economy, and we need to do more to educate the public of what this actually means.

I think a lot of people don't even know what the terms mean. When I talk with people and talk about untreated human waste entering our streams and Lake Erie, everyone is aghast, they don't know that that is still happening. So I think that's a big part of the challenge.

Another part of the challenge, I think, is looking at our definition of infrastructure. We need to look at non-point source methods of capturing of storm water. Storm water Phase II has two very good parts in it that deal with using the land as a filter before it gets into a pipe. I think we need to do that. I think there needs to be leadership on local, State, and national levels related to, for example, wetlands. We need to restore the protection that wetlands once had and, specifically, isolated wetlands.

So there are a number of things that we as communities and as States and a nation can do, in addition to sewage treatment infrastructure.

Senator VOINOVICH. Well, one of the things I think that you know, the EPA, Federal EPA, made all kinds of demands on communities. And one of the questions I've always had is that are those realistic demands? Combined sewer overflow, this has got to be done, as you know. Again, the communities can't do it themselves.

I keep referring back to the days when we did something, remember it was 75/25, in 1985 we knocked it out and went to the loan growth. We haven't seen very much progress since that time.

Are you all confident that we're capturing the numbers on the municipal waste? We're doing a good enough job?

I was kind of shocked to see that chart that was over at the boat where it showed that it's kind of the same. My thought would be from reading everything, you believe that we're really—that is really the case?

Mr. CULVER. Those are point source data and there is monitoring being done of some of the streams and rivers to capture non-point source and other sorts of things. We have a little problem, like the one for the Maumee River, the location of that sampling site is 10 miles upstream. So there might be something happening in the town of Toledo that we don't know about.

So there's a real need, if we're trying to model phosphorus flow through the Lake Erie ecosystem, if there's an error of 50 or 75 percent in the loading that's coming in those data, if they're off by that much, we simply cannot come up with an answer or prediction of what will happen in the future, because we're working—it would be like having a budget where there was expenditure that didn't show up on the ballot sheet. You simply can't plan under those circumstances or model.

Mr. HEATH. Also, part of the problem is that the inputs are episodic, and that monitoring does not always catch the highest input events because those are often occurring after storms, so you have agricultural non-point runoff and the combined sewer overflow problems are not always accounted for because of the episodic and the unpredictable nature of the input.

So I'm not satisfied that we know as well as we would like, regarding the inputs. And that if we miss even a small amount of those inputs in terms of time, we may be missing major events in terms of quantity estimates.

Senator VOINOVICH. What's the breakdown in terms of agricultural runoff versus municipal sewage?

Mr. HEATH. Well, I don't know, but we're in a largely agricultural watershed.

Senator VOINOVICH. The point I'm making, it gets back to allocation of resources, and I know, in Ohio, we really tried to work with the agricultural community in doing this no till farming and use less fertilizer and all of the other stuff.

So if we're going to invest money, where would you get the biggest return for your investment? If you had one choice, put more money into the agricultural runoff and sedimentation, or would you do the municipal?

Where would we get the biggest return on our dollar?

Mr. CULVER. The greatest year-to-year variation is in the stream flow or watershed, which would include the non-point source, so it really strongly responds to rainfall and so forth. But you might question whether or not the same number of dollars applied to a agricultural source would be as effective as where you had an institutionalized piece of equipment there, here's that storm water, treating the phosphorus in it, and reducing that to practical levels.

So it may well be that the effectiveness of the dollar would be higher for storm water controls and sewage treatment, but the total mass of phosphorus and the variation of that mass of phosphorus is greater for non-point source.

Mr. REUTTER. If we're putting in about 29 metric tons of phosphorus, the model says we had to get back to 11,000 metric tons,

now we are down to the point it's about two-thirds coming in from agricultural runoff, one-third from the other, we need research. Those models that say that should be our target, appear that they are no longer accurate. So we need to reassess the way phosphorus is moving through the system, how it's being cycled, how it's being used, because it's quite likely that in the given scenario we have right now, 11,000 is not right. It needs to be some other number.

So before we could really honestly tell you where the reduction should come, we should determine what level is now appropriate and acceptable because of the size of the reduction is going to have a big impact on where we say that we should take that.

Senator VOINOVICH. Dr. Culver, you, in your testimony, talked a little bit about the bacterial contamination of combined sewer overflows. Now we're talking about bacterial. How much of the dead zone problem is attributed to bacterial contamination?

Mr. CULVER. I don't think very much at all. I think the dissolved organic carbon coming from waste of that sort, really are severely diluted by the time we get out far enough off shore where we're getting anoxic zones. Problems for those are more where that water is being held, close to shore, where it will impact intakes for potable waters and the beaches, that she has already mentioned.

So I think, it's probably fair to say, that most of that effect will be near shore. It is clearly the case that sewage does have organic matter in it. It does consume oxygen when it's decomposed.

Senator VOINOVICH. So that problem is more for the beaches and more for the folks that are trying to provide us with clean water, but not this other problem?

Mr. CULVER. That's correct.

Mr. MATISOFF. I might add, it's two different kinds of bacteria. The one source, that you're concerned about, is the sewage source of bacteria. There are natural bacteria in the mud and our water column and out in our lake. Those are the ones that are consuming the oxygen in the bottom that we're talking about.

Senator VOINOVICH. You've heard each other testify, is there some comments that you would like to make regarding each other's testimony, or any other comments that you would like to share with me?

Mr. REUTTER. Senator, I request—I think we've been most successful in addressing this problem, by when it comes to Federal funds, by getting directed funds from EPA through the Great Lakes National Program Office and Sea Grant Program. Those two groups, I would be very confident, would be able to respond quickly to address this problem if additional funds were made available.

Senator VOINOVICH. Pardon me.

Don't we get our Army Corps of Engineers money, and then you get—your EPA comes out of a different budget, doesn't it? EPA comes out of what budget?

Ms. RANSOM. VA-HUD appropriations.

Senator VOINOVICH. VA-HUD, right, and then we get ours out of energy and water.

So that's sometimes the problem, because VA-HUD, you can imagine, think about that, EPA budget comes out of VA-HUD.

Mr. REUTTER. You could be very helpful. Sea Grant is part of NOAA. The Great Lakes Environmental Research Lab is part of

NOAA. It's currently going through a strategic planning process. They'll be going around the county to gather input on what should be incorporated into that strategic plan. They have identified five hearings that they want to have around the country.

One of the things that always frustrates me is that the Great Lakes never gets its due. Our coastline is longer than the east coast, west coast or the gulf coast.

Senator VOINOVICH. By the way, you have some wonderful statistical information in your testimony.

Mr. REUTTER. It's really a passion with me. We're often overlooked. And here's another example, five hearings around the country, the coasts are all covered except the Great Lakes coast. They have identified one hearing to be cover the Midwest and Great Lakes, and that hearing will be in Boulder, Colorado.

Senator VOINOVICH. Let's get this information down. Maybe we'll get involved with that.

When are these hearings again?

Mr. REUTTER. They're going to take place during the next six to 8 months.

Senator VOINOVICH. Who's doing it again?

Mr. REUTTER. This is NOAA. It would be really nice for you, just as you've done here, to offer to host a hearing right here in Cleveland. It would really get a focus for that particular issue.

Senator VOINOVICH. Well, there is no question that the Great Lakes have not received the attention that they deserve. Even with the Coast Guard, one of the things that we finally got them to do, even the admiral is knowledgeable about, in terms of infrastructure problems that are needed for transportation. You have them for the Mississippi River, you have them for the other places in the country, but we don't have that kind of plan in place. We don't have a priority list of projects that need to be undertaken to just facilitate movements of boats throughout the Great Lakes. It's just not there. And I think that we really need to do a better job of getting the Great Lakes legislatures to be more coordinated in their efforts.

I think that gets back, to a certain degree, with all the multiplicity of organizations. If you look at that list of organizations, you would throw up your hands. Who do you talk to? So perhaps we ought to get some folks together to talk about how we can do a better job of coordinating advocacy of the Great Lakes through various organizations that exist, so we can get the message across.

How about the gobies, are they a threat?

Mr. REUTTER. They're a threat to the fishery. The information on the botulism is a real interesting one, because it's possible that botulin is being transferred by gobies. That should be almost impossible. There is some things going on that we don't understand. There are also 14 other species of gobies that are poised and the ready to invade.

Senator VOINOVICH. Wait a minute, what do you mean poised to invade?

Are they here? Is the boat coming?

Mr. REUTTER. Hopefully, no, to both of those. But they're in the region that shipping comes from. The round gobies is one of those species is more salt tolerant, it could do more damage on our salt water coasts. They're clearly posing a human health problem be-

cause they're allowing contaminants to be transferred from zebra mussels to gobies to smallmouth bass. That is a target species for anglers.

Mr. CULVER. We've found that gobies attack nests of smallmouth bass. Someone catches the bass, it's supposed to be a fine thing, it happened to be on a nest, and while it's gone, the gobies move in and eat the eggs of the juveniles of the smallmouth bass.

Mr. Isbell can give you more information on that.

Mr. ISBELL. All of these things are changing the way things work.

Senator VOINOVICH. Well, it emphasizes that we have to have ongoing research in a lot of areas, if we're going to stay up on a lot of things. We have to take significant preventative efforts, one is this issue of ballast water. We have to get on that right away. Let's, at least, prevent anything new from coming in.

Mr. CULVER. The International Ecological Society has had meetings in which the Europeans, in particular, have identified invasive species that are moving around Europe, that are, as he says, poised. There is a species called amphipods and various sundry, other things, that are problems in Europe which we don't have yet, but which could easily get here by the same routes as the previous species. Those would make additional biological changes to the system.

Senator VOINOVICH. We have our work cut out, don't we?

Thank you very, very much for coming today. I really appreciate your taking time out of your schedules to share the information.

This will all go into the hearing record, and we'll have that available for the other members of my committee. And I'm anxious to get back from you some of the things that I requested of you.

I may have some other written questions that I may ask you to respond to.

Thanks very much.

[Whereupon, at 12:10 p.m., the committee was adjourned, to reconvene at the call of the Chair.]

[Additional statements submitted for the record follow:]

STATEMENT OF DAVID A. ULLRICH, DEPUTY REGIONAL ADMINISTRATOR, REGION 5, ENVIRONMENTAL PROTECTION AGENCY

Good morning Mr. Chairman and Members of the Committee. I am David Ullrich, Deputy Regional Administrator and Acting Regional Counsel for the Environmental Protection Agency (EPA) Region 5. I am here today representing Thomas V. Skinner, EPA's Great Lakes National Program Manager. I thank the Committee for the opportunity to speak with you today regarding a potentially troubling change in the Lake Erie ecosystem.

In my testimony today I will present a brief summary of the current situation and EPA's response to what we think may be occurring in the lake. I will try to address the Committee's questions regarding why anoxia is occurring in the central basin of Lake Erie, the effect of anoxia on the Lake Erie ecosystem, and solutions to prevent anoxia from occurring in the future. I will also be submitting for the record the Lake Erie Lakewide Management Plan, the proposal for the Lake Erie Supplemental Study of Trophic Status, and a copy of the Great Lakes Strategy. All of these documents will be explained during this presentation.

It was little over two decades ago that the U.S. and Canada spent literally billions of dollars on intensive efforts to upgrade sewage treatment plants, ban phosphorus from detergents, and improve agricultural nutrient management practices, all of which helped to bring Lake Erie back from the brink of disaster to one of the greatest environmental successes to date. Today, instead of sitting here in Cleveland on the shores of a dead lake, we now see the effects of a true environmental renais-

sance here on the Lake Erie shoreline. We can see the fruits of this economic rebirth that has been spurred by the cleanup and revitalization of the Cuyahoga River and of the lake itself. We have given the Lake Erie citizens back their lake along with the attendant recreational and economic opportunities, not the least of which is a billion dollar world-class walleye fishery.

To maintain this success, EPA continues to monitor nutrient levels as part of the Agency's Great Lakes National Program Office (GLNPO) annual intensive monitoring program. And because this program is in place, we started noticing troubling signs of a change in Lake Erie in the 1990's. Total phosphorus measurements, always considered a good indicator of the health of the lake, started to increase, after years of decrease. These results are corroborated by Canadian data. Perhaps more telling was the return of very low oxygen levels in a large area in the central basin of Lake Erie. This condition, whose technical name is "anoxia", has gained the term "the dead zone."

The appearance of the "dead zone" is not a new problem; it is something that EPA is quite familiar with and has successfully addressed in the past. But there is a new twist to the problem this time around. Our past experience identified external loadings of nutrients, principally phosphorus, as the main reason for the existence of anoxic conditions in the lake. EPA's Office of Research and Development helped create the models that set the targets for reduction of phosphorus to alleviate the anoxic condition in the lake. Once we reached these targets, the lake responded accordingly. Currently, however, our available information does not indicate any substantial or significant increases in loadings of phosphorus or other nutrients to Lake Erie from external sources. So something different seems to be taking place.

One may rightly ask if we should be concerned about these changes in Lake Erie. My answer to that is an emphatic yes. We should be concerned because there are a number of possible large-scale and potentially very costly impacts due to the changes we are observing. These changes could include:

- Impacts on the Lake Erie Fishery and Other Wildlife: There are indications that a variety of changes are taking place that may seriously impact the Lake Erie fishery. Larger areas and/or increased duration of reduced oxygen levels in the water could lead to reductions in the food base for fish populations, such as walleye. We also have recent indications that burrowing mayfly larvae, another part of the food base for many Lake Erie fish populations are being severely diminished along the edges of the lake's central basin. These losses indicate that future reductions of fish populations may occur.

We have also seen four straight years of large-scale fish and bird die-offs, partly due to type E botulism which was last seen in the Great Lakes in the 1960's but had never been found in Lake Erie. Mud puppies, an aquatic salamander, sheepshead, rock bass and smallmouth bass have all experienced kills during this period.

At the same time, avian botulism has caused the deaths of thousands of water birds, including common loons and ring-billed gulls.

The presence of botulism in the lake may be due to the impact of exotic species, such as the round goby, and the quagga and zebra mussels.

Such changes in the Lake Erie ecosystem as outlined above could lead to the formation of a fishery from one dominated by top sport fish such as walleye and salmon to one dominated by bottom feeders. Such a change would have serious implications for Lake Erie's billion-dollar fishery.

- Beach Closures and Loss of Recreational Opportunities: We are observing many impacts of increased phosphorus levels in the lake, including large, unsightly and smelly mats of algae called Cladophora washing up on beaches, leading to beach closures and seriously impacting recreational opportunities for Lake Erie residents.
- Impacts on Drinking Water Quality: Microcystis blooms (a form of blue-green algae) are also occurring. These blooms are thought to be a direct result of a combination of over-enrichment of the lake and the zebra mussel infestation. As these large blooms die and sink to the bottom, they commonly release chemicals that can produce a foul odor and musty taste that can be detected in tap water.
- Present and Future Impacts of Exotic Species: If these changes are related to zebra mussel invasion of the Lake, then what we are observing may be the tip of the iceberg. As other exotic species establish themselves, the Lake may go through continual disruptions in its biology.
- Lake Erie is the proverbial "Canary in the Coal Mine": Due to its relatively short water retention time, Lake Erie is ecologically susceptible and often the first of the Great Lakes affected by chemical and biological change. It is a bellwether for parts of the other Great Lakes, especially for shallow embayments such as Saginaw Bay, Michigan and Green Bay, Wisconsin.

So, clearly there are ample reasons to justify our concerns regarding the changes in the Lake Erie ecosystem. But why is this happening again and what is different about the current situation as compared to the problem in the 1960's, 1970's, and 1980's?

Many scientists suspect that zebra mussels and other exotic species such as round gobies are starting to reshape Lake Erie's ecosystem in ways that lake researchers have yet to fully fathom. Others theorize that the lake may be suffering from the combined effects of increased temperatures and lower lake levels. Whatever the reason, I am here today to assure this Committee and the public that EPA is keenly aware of the reoccurrence of this problem and that we are already taking steps to address many of the concerns raised in this hearing through activities that have been underway for some time. I will elaborate on two of these.

In response to our identification of rising levels of phosphorus in Lake Erie, GLNPO has undertaken the $2M Lake Erie Supplemental Study of Trophic Status which began on June 17, 2002, and which is being cooperatively funded and managed by GLNPO ($500,000), Environment Canada, and a roster of the preeminent Lake Erie experts from more than 20 universities and institutions, including Ohio University, the Ohio State University, and Case Western Reserve University among others.

EPA is very pleased by the level of commitment of the researchers involved in this study. We view the study results as the critical element in our ability to address the issue of Lake Erie's changing ecosystem.

Mr. Chairman, I feel strongly that the Lake Erie Supplemental Study of Trophic Status, which is currently funded, already underway, and being conducted in full cooperation with the Canadian government will help us identify, if not answer, many of the questions this committee has raised, and will help guide our solutions.

The other effort which must be mentioned is the Lake Erie Lakewide Management Plan, or LaMP, that has been underway since 1995 and which includes participation by both Canadian and U.S. Federal, Provincial, State, and non-governmental organizations.

LaMPs are required under the 1987 amendments to the Great Lakes Water Quality Agreement, originally signed by the United States and Canada in 1972. This historic agreement, created under the 1909 Boundary Waters Treaty between the U.S. and Canada committed both countries "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes basin ecosystem". There is also a statutory requirement in the Great Lakes Critical Programs Act of 1990 that requires EPA to develop LaMPs for each of the Great Lakes.

LaMPs are cooperative binational plans of action to assess, restore, protect and monitor the health of the individual Great Lakes. They are used to coordinate the work of the many governmental and non-governmental partners involved in managing the Great Lakes. EPA and Environment Canada are the Federal co-leads for the Lake Erie LaMP. Other LaMP member agencies include 6 State and 3 Federal agencies in the U.S., 3 provincial and 3 Federal agencies in Canada, and one binational commission.

LaMPs are shining examples of the ecosystem approach—the belief that management efforts should address environmental, economic and social factors in an integrated manner along ecological, rather than geopolitical, boundaries.

The Lake Erie LaMP has already developed measures and recommendations to improve water quality, environmental quality, recreation, fish and wildlife habitats, and has identified remedies to address associated problems in the Lake Erie basin. The LaMP considers all existing relevant programs at all levels of government as well as at non-governmental agencies that can be used to implement the required remedial actions. And more importantly, the actions identified in the LaMP have been approved by the Canadian and U.S. Federal, State and provincial agencies involved in the effort.

In terms of phosphorus and other nutrients, it is the goal of the Lake Erie LaMP that inputs from both point and non-point sources be managed to ensure that loadings are within bounds of sustainable watershed management. Currently, the Great Lakes Water Quality Agreement allows a maximum of 11,000 metric tons per year of phosphorus loadings from point and nonpoint sources.

The Lake Erie Supplemental Study of Trophic Status will work with the LaMP to inform and support its goals for addressing nutrient issues within the basin, as well as other LaMP goals which seek to address problems related to water quality and environmental quality.

I want to also mention that the work we are doing in Lake Erie supports the goals and objectives of the multi-agency U.S. Policy Committee's Great Lakes Strategy 2002 which was announced by EPA Administrator Whitman on April 2, 2002. This

Strategy is a shared expression of the partners at the U.S. Federal, State, and tribal levels of government, working together to restore and protect the Great Lakes.

Given that we are aware of the problem, that we have a scientific study in place to help us understand the situation and the decision support system required, and we have the LaMP as the proper delivery mechanism for the needed actions, what should our next steps be?

We need to develop a full understanding of the relationship between external phosphorus inputs and the anoxia problem. There is no indication at this time that loadings from any sources have increased. There may be a need for more intensive monitoring of tributaries to Lake Erie and for a review of point source permits and compliance with their limits to see if there are facilities that may be inadvertently contributing to the present change in conditions. Before re-examining the phosphorus targets for Lake Erie we need to, at the very least, insure that existing programs to control and reduce point and nonpoint sources of nutrients to Lake Erie are fully implemented.

Any future work on resetting binational phosphorus targets for Lake Erie would require extensive negotiations with our Canadian colleagues to revise the Great Lakes Water Quality Agreement. This would have to be followed by in-depth Federal-State discussions regarding what would be needed to achieve any newly set targets. Any such negotiations would need to be based on good monitoring data, ecosystem models (such as those developed by EPA's Office of Research and Development and GLNPO to diagnose the cause or causes of the decreased oxygen), and sound science.

A likely part of any long-term solution to the problem may be to aggressively address and limit the introduction of exotic species into the Great Lakes. If zebra mussels are identified as the root cause of the anoxic conditions in Lake Erie, then we will need actions above and beyond the scope of what EPA can do to address this problem and to prevent future introductions that could cause even more problems in the lakes. I am sure you are all aware of the Asian Big Head Carp that is moving up the Illinois River and could enter the Great Lakes in the very near future. These voracious bottom feeders would further muddy an already complicated ecosystem in Lake Erie and in the rest of the lakes.

In conclusion, I want to reiterate that what is happening in Lake Erie is not something new, but it's root causes may be. EPA is aware of this problem and we have mobilized the resources and expertise to help us determine what actions are needed to address this troubling situation.

I again thank the Committee for the opportunity to address this important issue for the Great Lakes. I would be happy to take any questions that you may have.

RESPONSES OF DAVID A. ULLRICH TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Mr. Ullrich, please provide me with a summary of the funding sources available for research on Lake Erie.

Response. There are several potential funding sources for Lake Erie research. Federal agencies that provide funds include NOAA (Sea Grant) and the U.S. Environmental Protection Agency (EPA), including EPA's Great Lakes National Program Office. The State of Ohio has provided funding in the past through the Lake Erie Protection Fund, the Ohio Environmental Protection Agency, and the Ohio Department of Natural Resources.

Question 2. Mr. Ullrich, what, if any, research of the Lake Erie "dead zone" has been funded by the Great Lakes Protection Fund?

Response. The Great Lakes Protection Fund has not directly supported any research on Lake Erie anoxia. The Lake Erie Protection Fund, however, has supported almost $2 million in projects that address the changing Lake Erie ecosystem. These projects have served as a springboard for the EPA Lake Erie supplemental study.

Question 3. Mr. Ullrich, are the targets for the reduction of external phosphorus inputs into Lake Erie set appropriately? Do they need to be revised?

Response. Phosphorus reduction targets were based on water-quality models developed in the mid–1970's. Decreased phosphorus trends and improved oxygen levels throughout the 1980's indicate that external phosphorus loading targets have been appropriate until recently. Research efforts are underway to determine the reasons for the increases in phosphorus levels. Determinations about the P loading targets cannot be made until this research is complete.

Question 4. Mr. Ullrich, how are aquatic nuisance species changing Lake Erie's ecosystem? What is U.S. EPA doing to address aquatic nuisance species already es-

tablished in the Great Lakes and to prevent the future introduction of additional species?

Response. Aquatic nuisance species (ANS) severely impact the Lake Erie ecosystem in multiple ways. ANS in Lake Erie have caused ecological changes to the lake by modifying the food web, changing water clarity, and disrupting predator/prey relationships. ANS are partially responsible for decreased populations of walleye and trout in parts of Lake Erie. One nuisance species, the round goby, may be responsible for the increase in Botulism E outbreaks in Lake Erie's eastern basin. Botulism E is communicable to humans. Furthermore, zebra mussels may cause sediment-bound phosphorus to "recycle" through the lake, contributing to the larger and more frequent dead zones and algal blooms within Lake Erie's central basin.

Once introduced and established in an ecosystem, ANS can be impossible to eradicate. Even when control technology exists, these efforts are burdensome and costly. For example, over $10 million a year is spent on sea lamprey control to protect the Great Lakes fishery. Unfortunately, control technology does not exist for most ANS.

EPA focuses on supporting efforts to prevent the future introduction and establishment of aquatic nuisance species. EPA has supported the development of an electrical barrier at the Chicago Sanitary and Ship Canal to prevent the exchange of organisms between the Great Lakes and Mississippi River systems. The agency is also working with the Great Lakes Commission to establish a rapid response plan that would coordinate Federal, State, and local responses to eliminate new introductions before they have a chance to become established. EPA is continuing to pursue several efforts that would decrease the threat of new introductions via ballast water from cargo ships. In coordination with NOAA and USCG, we are investigating the threat of so-called "NOBOB" (no ballast on board) vessels. (These vessels have pumped out their ballast tanks prior to entering the Great Lakes system, however there are still organisms in the residual, unpumpable ballast that remains in their tanks.) EPA has also contributed to the funding of ballast water treatment methods, in particular the testing of ozone and UV technology. Finally, EPA has funded a wide variety of ANS education/outreach efforts.

The Great Lakes Panel on ANS, established in the early 1990's, advises the national ANS Task Force and coordinates prevention and control efforts and education/outreach activities within the Great Lakes. EPA's Great Lakes National Program Office has long been an active member of the Great Lakes Panel on ANS.

Question 5. Mr. Ullrich, how many beach closures in Ohio last year were caused by Algae or bacteria discharged from municipal sewer systems?

Response. Of 51 Ohio Lake Erie beaches that reported on their status in 2001, 13 reported no-swimming advisories, all due to elevated levels of indicator bacteria. High levels of these bacteria indicate the possible presence of fecal contamination. Thirteen beaches were under no-swimming advisories for a total of 342 beach days. Eight-two percent of the advisory postings were related primarily to storm water runoff; 5 percent were due to sewage-system overflows, and 13 percent of the advisories were due to unknown sources.

Question 6. Mr. Ullrich, how exactly is the lake's ecosystem affected by climate changes and lower lake levels?

Response. The regional or localized impacts of global climate change cannot be predicted with any confidence at this time. In its June 2001 Report, Climate Change Science: An Analysis of Some Key Questions, the National Academy of Sciences cautioned: "Because there is considerable uncertainty in the current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments (either upward or downward)." And the United States' recent Climate Action Report—2002, that was submitted to the United Nations Framework Convention on Climate Change in May, further advised: "One of the weakest links in our knowledge is the connection between global and regional predictions of climate change. The National Research Council's response to the President's request for a review of climate change policy specifically noted that fundamental scientific questions remain regarding the specifics of regional and local projections. Predicting the potential impacts of climate change is compounded by a lack of understanding of the sensitivity of many environmental systems and resources—both managed and unmanaged—to climate change."

While science cannot currently answer whether climate change would lower or

raise Great Lakes levels, it is understood that lower lake levels influence the severity of the dissolved oxygen problem in the central basin. And higher temperatures would cause increased rates of oxygen loss. The warmer the water, the faster the organisms use oxygen and the less oxygen the water is physically capable of holding. Lower lake levels reduce the total volume of the layer of cooler bottom

water, thereby making the oxygen depletion occur more quickly in this layer. Higher temperatures would also have the likely effect of extending the period of seasonal stratification, giving more time for oxygen depletion to occur.

Question 7. Mr. Ullrich, how successful have binational agreements such as the Great Lakes Water Quality Agreement and the Boundary Water Treaty been in Restoring the Great Lakes fishery and ecosystem? What were the particular challenges and goals identified in these agreements? What still needs to be done to achieve those goals?

Response. The Great Lakes Water Quality Agreement (GLWQA)—an executive agreement established in 1972 under the Boundary Water Treaty of 1909—has been very successful in guiding the U.S. and Canadian Great Lakes programs. It continues to be a model for international cooperation on a shared natural resource. EPA has hosted many foreign visitors who have requested briefs on the Agreement in order to use it as a model in their home countries.

The original GLWQA of 1972 focused on the problem of excess nutrients. It set goals for phosphorus loadings, including those that led to the restoration of Lake Erie. The 1978 revisions emphasized controls for toxic contaminants. Specific objectives for many contaminants were established to help guide U.S. and Canadian domestic pollution reduction programs, and as a result, contaminant levels in fish and colonial nesting birds have been significantly reduced. This is particularly true for DDT and PCBs. The 1987 revisions to the GLWQA focused on using an "ecosystem approach" and established the use of Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs). These management plans are holistic efforts that move beyond problems caused solely by toxic contaminants to address ecosystemic problems such as habitat loss and impacts on fish and wildlife populations.

It should be noted that the Great Lakes Fishery Commission, which was established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries, coordinates fisheries research, controls the invasive sea lamprey, and facilitates cooperative fishery management, including stocking, among the Federal, State, provincial, and tribal natural resource management agencies. The Commission develops fishery management plans and fish community goals for each of the Great Lakes. For example, the LaMPs are coordinating their goals with those contained in the fishery management plans. The GLWQA has helped restore and protect aquatic habitats, improve water quality, and limit inputs of toxic contaminants, resulting in improved conditions that promote the health of the Great Lakes fishery.

The Great Lakes Strategy of 2002 (www.epa.gov/grtlakes/gls/glstoc.html, also attached) identifies high-priority, basin-wide activities that need to be accomplished to fulfill the goals of the GLWQA. Lake-specific activities are identified in the LaMPs and the Great Lakes Fishery Commission's fishery management plans.

Question 8. Mr. Ullrich, what are U.S. EPA's priorities for Lake Erie?

Response. The collective, basin-wide vision for the Great Lakes is outlined in the Great Lakes Strategy of 2002:

- The Great Lakes Basin is a healthy natural environment for wildlife and people.
- All Great Lakes beaches are open for swimming.
- All Great Lakes fish are safe to eat.
- The Great Lakes are protected as a safe source of drinking water.

Shared binational goals more specific to Lake Erie are outlined in the Lake Erie Lakewide Management Plan. Through international agreement, EPA takes the U.S. lead in developing and implementing this plan. The EPA, through its partnership work with other Federal and State agencies in the United States and with the Federal and Provincial governments of Canada, has adopted an ecosystem approach to restoring and maintaining the physical, chemical, and biological integrity of Lake Erie. The most recent Lake Erie LaMP was published in Spring 2002 (www.epa.gov/grtlakes/lakeerie/2002update/index.html).

The Lake Erie LaMP uses an adaptive-management approach, depending on senior management decisions to change priorities according to unexpected and often disturbing trends within the lake, such as the anoxia trend in the central basin. In broad terms, the Lake Erie LaMP bi-national work group has envisioned a future Lake Erie in which phosphorus and nitrate loadings from all sources are reduced, and critical ecosystem habitat is restored, enhanced, and maintained for current and future generations.

Accordingly, key EPA strategic actions within the Lake Erie basin have focused on, and will continue to focus on, demonstrating and encouraging activities to reduce phosphorus and nitrate loadings to Lake Erie, and will focus on habitat-restoration and preservation activities.

Many of these activities will require EPA to work closely with State and local governments, since those governments hold the primary jurisdiction to conduct many of the actions necessary to improve the physical, chemical and biological integrity of Lake Erie.

Question 9. Mr. Ullrich, given all the Federal, State, local, international, and non-profit entities involved in restoring and protecting the Great Lakes, how can all these efforts be better coordinated and funding sources be stretched farther?

Response. The framework for multi-agency, multi-organization coordination is in place for the Great Lakes.

The Lake Erie Lakewide Management Plan (LaMP) identifies problems, establishes goals and initiates management actions to address the beneficial-use impairments of Lake Erie. The LaMP work group and management committee is comprised of a variety of binational Federal, State, provincial, and non-profit agencies that have responsibilities for pollution control and natural resource management. Through the LaMP, opportunities to creatively use limited resources are identified and pursued to the extent practicable.

At the domestic, basin-wide scale, the Great Lakes Strategy of 2002 was created to help coordinate and streamline efforts of the many governmental partners involved with protecting the Great Lakes. The Strategy is managed by the U.S. Policy Committee, a forum of senior-level U.S. representatives from the Federal, State, and Tribal agencies responsible for environmental and natural resources management of the Great Lakes. The Strategy focuses on multi-Lake and basin-wide environmental issues and establishes common goals that the governmental partners will work toward.

On a binational, basin-wide scale, activities are coordinated through the Binational Executive Committee (BEC), a forum of U.S. and Canadian senior managers. The BEC supports the assessment and reporting of health of the Great Lakes through the State of the Lakes Ecosystem Conference (SOLEC), as required under the terms of the GLWQA, and through the State of the Great Lakes biennial report issued by the SOLEC steering committee. BEC discussions are also currently underway to improve coordination of Great Lake monitoring programs.

Question 10. Mr. Ullrich, how can we improve phosphorus monitoring data and ecosystem modeling in the Lake Erie basin?

Response. EPA's Great Lakes National Program Office's annual monitoring program continues to provide data on P concentrations in the lake. Improvements in phosphorus trend and ecological monitoring potentially could be facilitated by:

- An assessment of total loadings to determine how much phosphorus is going into Lake Erie.
- More extensive source monitoring to determine where phosphorus originates. This requires estimating contributions from both point sources, including waste water treatment plants (WWTP), and non-point sources, including agricultural runoff, combined sewer overflows (CSOs), and storm sewer overflows (SSOs).

Models exist for Lake Erie, but they may need to be rebuilt to take into account the changes to this important ecosystem, particularly the influences of non-native species (i.e., the relationship between zebra mussels and phosphorus cycling within Lake Erie). Any changes to monitoring and ecosystem modeling for Lake Erie would occur in the context of available Federal, State, and Provincial resources.

INTRODUCING THE GREAT LAKES STRATEGY 2002: A PLAN FOR THE NEW MILLENNIUM

DEVELOPED BY THE U.S. POLICY COMMITTEE FOR THE GREAT LAKES

U.S. ARMY CORPS OF ENGINEERS—U.S. ENVIRONMENTAL PROTECTION AGENCY-U.S. COAST GUARD

U.S. DEPARTMENT OF AGRICULTURE—NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. FISH AND WILDLIFE SERVICE—U. S. GEOLOGICAL SURVEY

- Agency for Toxic Substances' and Disease Registry—U.S. Forest Service Great Lakes Fishery Commission

ILLINOIS INDIANA MICHIGAN MINNESOTA NEW YORK OHIO PENNSYLVANIA' WISCONSIN

GREAT LAKES TRIBAL GOVERNMENTS

As the largest freshwater system on the face of the earth, the Great Lakes ecosystem holds the key to the quality of life and economic prosperity for tens of millions of people. While significant progress has been made to restore the environmental health of the Great Lakes, much work remains to be done. Chemical or biological contaminants still limit our ability to eat the fish we catch. Prevent us from swimming at our public beaches, and can make us vulnerable to health problems. Natural areas have been degraded, and the diversity of our fish and wildlife populations is increasingly threatened. The U.S. Policy Committee has developed Great Lakes Strategy 2002 to advance Great Lakes protection and restoration efforts in the new millennium.

Great Lakes Strategy 2002 was created by the U.S. Policy Committee—a forum of senior-level representatives from the Federal, State, and Tribal agencies responsible for environmental and natural resources management of the Great Lakes—to help coordinate and streamline efforts of the many governmental partners involved with protecting the Great Lakes. The Strategy focuses on multi-Lake and basin-wide environmental issues and establishes common goals that the governmental partners will work toward. It supports existing efforts underway, including Lakewide Management Plans and Remedial Action Plans for Areas of Concern, by addressing issues that are beyond the scope of these programs and helping integrate them into an overall basinwide context. It also advances the implementation of the United States' responsibilities under the Great Lakes Water Quality Agreement of 1987;

The Strategy was developed cooperatively by the Federal, State, and Tribal, members of the U.S. Policy Committee, with the consultation of the Great Lakes public. Public workshops. were held throughout the basin—in Duluth, Chicago, Detroit, and Niagara Fails—to solicit comments from local governments, industry, nongovernmental environmental organizations, and the general public. Together we have developed a shared, long-range vision for the Great Lakes:

The Vision—The Great Lakes Basin is a healthy natural environment for wildlife and people

- All Great Lakes beaches are open for swimming.
- All Great Lakes fish are safe to eat.
- The Great Lakes are protected as a safe source of drinking water.

In support of this vision, the member agencies of the U.S. Policy Committee commit to work together to "protect and restore the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem." The Strategy sets forth specific objectives and actions that will reduce contaminants, restore habitat, and protect the living resources of the basin. Specific objectives in this ambitious plan include:

- By 2005, clean-up and delist 3 Areas of Concern, with a cumulative total of 10 by 2010.
- By 2007, reduce concentrations of PCBs in lake trout and walleye by 25 percent..
- By 2007, establish 300,000 acres of buffer strips in agricultural lands.
- By 2010, 90 percent of Great Lakes beaches will be open 95 percent of the season.
- By 2010, restore or enhance 100,000 acres of wetlands in the Basin.
- By 2010, substantially reduce the further introduction of invasive species, both aquatic and terrestrial, to the Great Lakes Basin Ecosystem.
- Accelerate the pace of sediment remediation, leading to the clean-up of all sites by 2025.

Great Lakes Strategy 2002 will guide the efforts of the governmental partners in the U.S. Policy Committee for several years. Working with the broader Great Lakes community, the U.S. Policy Committee looks forward to implementing this "Great Plan for the Great Lakes."

RENEWING THE PARTNERSHIP

Since the signing of the 1972 Great Lakes Water Quality Agreement (GLWQA), programs and policies to restore and protect the Great Lakes have served as a worldwide model for inter-jurisdictional cooperative environmental protection arid natural resource management. Toxic substances in the environment have been greatly reduced and the ecosystem shows signs of recovery. Billions of dollars in wastewater Infrastructure Improvements arid bans, on high phosphate household detergents have largely addressed the excess nutrient loads which choked the Great Lakes with nuisance algae. The treatment of Industrial effluent discharges has

greatly improved water quality. Multimedia Initiatives to prevent pollution from persistent, toxic substances, have evolved to become a national program. Multi-stakeholder lake-wide and local stewardship initiatives are serving to Identify and protect habitats which support an important variety of plants, fish, terrestrial, wildlife, and other important species found in this world-class freshwater ecosystem. Despite these impressive accomplishments, much work remains to be done to ensure a healthy Great Lakes ecosystem.

Great Lakes Strategy 2602 (hereunder the "Strategy') was created by the U.S. Policy Committee (USPC)—a forum of senior-level representatives from the Federal, State, and Tribal governmental agencies that share responsibility for environmental protection and natural resources management of the Great Lakes—to advance the restoration and protection of the Great Lakes Basin Ecosystem. The purview of this Strategy is focused on U.S. Federal, State and Tribal government environmental protection and natural resource management activities as they relate to fulfilling the goals of the GLWQA.[1] Activities such as economic development, while related the goals of this Strategy, are not specifically addressed. This Strategy will serve to coordinate and streamline efforts of the USPC, by focusing and establishing a set of common goals on high priority multi-Lake and basin-wide environmental issues. The Strategy employs and supports multi-stakeholder environmental protection efforts in the Great Lakes, such as Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs) for Areas of Concern (AOCs), by integrating them in an overall basin-wide context to address issues that are beyond the individual scopes of these programs.

The restoration and protection of the Great Lakes ecosystem is a massive undertaking. This international watershed Includes two nations, eight U.S. States, a Canadian Province[2] , more than 40 Tribes and First Nations[3], and many local governments. Only through a cooperative partnership can we ensure its health. Great Lakes Strategy 2002 will guide the efforts of the USPC for the next several years. Working with the broader Great Lakes community, the USPC looks forward to implementing this "Great Plan for the Great Lakes."

Why the Great Lakes Are Important Regionally, Nationally, And Globally

The Great Lakes basin is home to more than 30 million people. It is where many of us live, work, and play. The Great Lakes—deep fresh water seas—are the largest system of surface freshwater on the Earth, spanning about 800 miles and containing about 20 percent of the world's surface freshwater resource (5,500 cubic miles or about six quadrillion gallons of water). The water in the Great Lakes accounts for more than 90 percent of the surface freshwater in the United States. In the United States, the Great Lakes are considered a fourth seacoast. The total shoreline (U.S. and Canadian, including connecting channels and islands) is more than 10,000 miles, or about 40 percent of the earth's circumference.

The Great Lakes basin holds major urbanized areas that are home to more than one-tenth of the population of the United States and one-quarter of the population of Canada (a total of more than 33 million people). Over 30 million people in the United States and in Canada rely on the Great Lakes watershed as a source of drinking water.

The basin contains many thriving, ecologically rich areas. The Great Lakes ecosystem includes such diverse elements as northern evergreen forests, deciduous forests, tall grass and lake plain prairies, sandy barrens, alvars, dunes, and coastal wetlands. Over 30 of the basin's biological communities and over 100 species are globally rare or found only in the Great Lakes basin.

The wealth of natural resources has long made the region a heartland of both the U.S. and Canadian industrial economy. Economic activity in the Great Lakes basin exceeds $200 billion a year. There are notable concentrations of multi-sector manufacturing facilities in each of the Great Lakes States. The Region generates more than 50 percent of the total U.S. manufacturing output. About one-third of the Great Lakes basin's land is in agricultural use. The eight Great Lakes States account for 30 percent of nationwide agricultural sales, a $45 billion industry. The international shipping trade annually transports 50 million tons of cargo through the Great Lakes. Main commodities are grain, iron ore, coal, coke, and petroleum

[1]The GLWQA, first signed by President Nixon and Prime Minister Trudeau in 1972, establishes a joint, binational commitment by the United States and Canada to restore and maintain the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem.

[2]While not located within the Great Lakes Basin Watershed, the Province of Quebec is a partner in Annex 2001 of the Great Lakes Charter and other Great Lakes initiatives.

[3] Canada refers to communities of indigenous people as "First Nations".

products. Almost 50 percent of this cargo travels to and from oversea ports, especially Europe, the Middle East, and Africa.

Recreation is also an important part of the economy. The annual value of the commercial and sport fishery is estimated at over $4.5 billion. The eight Great Lakes States have about 3.7 million registered recreational boats, or about one-third of the Nation's total. The 600-plus State parks in the Region accommodate more than 250 million visitors each year. It has been estimated that nearly 5.5 million hunters spend more than $2.6 billion annually. A four season climate supports many other types of recreation.

The economic potential of the Great Lakes region is closely tied to the health of the ecosystem. The challenge of Great Lakes environmental protection and natural resource management is to balance the use of the resources of this unique ecosystem with its protection, restoration, and conservation.

Our Commitment

Despite their large size, the Great Lakes are sensitive to a wide range of stressors,. including toxic pollution, invasive species, and habitat degradation. The USPC is dedicated to combating these and other important stressors in order to carry out our mission to restore and protect the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem for the benefit of its citizens and future generations. In addition, the USPC will strive to ensure that the Great Lakes Region does not adversely affect other ecosystems, outside and/or downstream of the Basin. The USPC has been working to address these problems since the early 1990's, following the development of the previous Great Lakes Strategy. This Strategy Is a re-commitment that expands upon and incorporates lessons learned from that endeavor.

The USPC fully supports the achievement of the goals, objectives, and actions set forth In this Strategy and will use it to monitor and evaluate progress. The near-term goals, objectives, and actions' are intended to be ambitious but achievable given current funding, resources, and regulatory requirements. Recognizing that governmental agencies' budgets are appropriated annually or biennially, successful implementation will depend, in part, on continued adequate funding and resources and on-going implementation and enforcement of current regulatory requirements. The mid-term goals, objectives, and actions represent the USPC's assessment of reasonable progress over a longer timeframe, while recognizing that there is a significant degree of uncertainty Involved with protecting and restoring a large, dynamic ecosystem such as the Great Lakes. The USPC will review and adjust these mid-term targets, as appropriate, to manage protection and restoration efforts hi an adaptive manner. The Strategy should not be construed as a commitment by the U.S. Government for additional funding and resources for its implementation. Nor does it represent a commitment by the U.S. Government to adopt new regulations. In future meetings, where warranted, the USPC will carefully consider and recommend corrective measures to facilitate Strategy implementation. The USPC will update the Strategy periodically. International issues will be discussed between the USPC and Canadian counterparts at Binational Executive Committee (BEC) meetings, a similar high-level forum with representatives from both countries, which are typically conducted twice a year.

Our Long-Term Vision

The people of the Great Lakes Region will know we have been successful in our environmental protection efforts when the need to issue health advisories for fish consumption, beaches, or drinking water is eliminated; the aquatic environment supports a balanced, self-sustaining fishery; the full range of native species, natural communities and ecological systems are restored and protected; land use and water quantity decisions are made with a comprehensive understanding of the environment; and environmental, and economic prosperity are maintained in a sustainable balance.

This long-term vision can be expressed simply, as follows:

The Vision: The Great Lakes Basin is a healthy natural environment for wildlife and people.

- All Great Lakes beaches are open for swimming.
- All Great Lakes fish are safe to eat.
- The Great Lakes are protected as a safe source of drinking water.

Our Collective Goals and Priorities

In keeping with our mission and long-term vision for the Great Lakes, the member agencies of the IJSPC will work together to protect and restore the chemical,

physical, and biological integrity of the Great Lakes Basin Ecosystem. Accordingly, we have expressed our strategic priorities under four major goals:

1. Chemical Integrity—Reduce toxic substances in the Great Lakes Basin Ecosystem, with an emphasis on persistent bioaccumulative toxic (PBTs) substances, so that all organisms are protected. Over time, these substances will be virtually eliminated. Maintain an appropriate nutrient balance In the Great Lakes to ensure aquatic ecosystem health.

2. Physical Integrity—Protect and restore the physical integrity of the Great Lakes, supporting habitats of healthy and diverse communities of plants, fish and other aquatic life, and wildlife In the Great Lakes Basin Ecosystem. Protect Great Lakes water as a regional natural resource from non-sustainable diversions and exports. Promote improved land use practices and the enhancement of the Great Lakes Basin as a source of recreatio n and economic prosperity.

3. Biological Integrity-Protect human and biological health. Restore and maintain stable, diverse and self-sustaining populations of predominantly native fish and other aquatic life, wildlife, and plants In the Great Lakes Basin Ecosystem. Control and eliminate pathogens and prevent the introduction and spread of invasive species, to protect human health, ecological health, and economic vitality.

4. Working Together—Work together as an environmental community to establish effective programs, coordinate authorities and resources, report on progress, and hold forums for information exchange and collective decisionmaking, so the Great Lakes are protected and the objectives of the GLWQA are achieved. This last goal acknowledges the management and institutional challenges to effectively coordinate programs and authorities to achieve the restoration and protection of the Great Lakes.

Under each of the four goals, this Strategy identifies major environmental challenges facing the Great Lakes Basin Ecosystem. Each section, which represents a specific environmental challenge, provides a description of the issue, lists the major current or future governmental program(s) to address the issue, sets forth an ambitious objective(s), which typically includes a date and a measurable environmental outcome, and lists specific key actions to achieve or support the objective(s). Some of the key actions in a particular section may support a variety of environmental objectives in the Strategy, but are listed only once to avoid redundancy.

Chemical Integrity: Reducing and Eliminating the Threat of Toxic Pollution and Excess Nutrients

Goal: To reduce toxic substances in the Great Lakes Basin Ecosystem—with an emphasis on persistent toxic substances—so that all organisms are adequately protected. Over time, these substances will be virtually eliminated. Maintain and appropriate nutrient balance in the Great Lakes to ensure aquatic ecosystem health.

Due in part to the long retention time of water in the system (up to 190 years in Lake Superior), the Great Lakes are adversely impacted by toxic substances. Substances which are persistent and bioaccumulate are the greatest threat. The presence of toxic substances at certain concentrations can negatively impact human health. For example, there are currently numerous fish advisories in the Great Lakes which indicate that toxic substances are still accumulating in the food chain at unacceptable levels. In addition, new research is identifying potential emerging problems with respect to toxic substances. The possible endocrine disrupting nature of some chemicals could be the cause of human health effects of serious concern.

The sources of pollution include air deposition, industrial and municipal dischargers, previously contaminated sediments, runoff from farms and urban areas, and contributions of pollution from waste sites. Much progress has been made to decrease the threat of toxic substances in the Great Lakes Basin. Levels of most toxic substances' have significantly decreased over the time. However, chemical inputs to the Great Lakes still continue, causing unacceptable concentrations of these chemicals in water and fish tissue. Many of these toxic inputs are the result of air deposition and may come from other areas of the continent, or from global long-range transport. Achieving further reductions, leading to the virtual elimination of PBTs, is still a major priority.

The Great Lakes Region has long been a site for innovative regulatory efforts to protect human health and the health of the environment Efforts such as the phase-out of mixing zones (the use of dilution to reduce concentrations in. discharges) for PBTs are now in place and may serve, as models fox the rest of the Nation, where appropriate.

IMPLEMENTING THE GREAT LAKES INITIATIVE

A number of regulatory programs provide a foundation for the cleanup and protection of the Great takes. An important tool was developed through the Great Lakes

Water Quality Initiative (GLI). USEPA and the States developed the Great Lakes Water Quality Guidance (the Guidance) that Includes water quality standards and implementation procedures for the Great Lakes system. It consists of water quality criteria to protect aquatic life, human health, and wildlife, and contains antidegradation policies and implementation procedures specific to the Great Lakes. Equally important, it provides methods for deriving water quality criteria that can reflect bioaccumulation and chemical additivity, providing States and Tribes with a tool to address a universe of pollutants that might affect the Great Lakes. In addition, the Guidance provides a method for States to implement their narrative water quality criteria ("no toxics in toxic amounts"), even when there are not enough data to support a numeric water quality criterion. This program is expected to reduce direct toxic water discharges by six to eight million pounds per year.

Water quality standards and National Pollutant Discharge Elimination System (NPDES) permit implementation rules consistent with the Guidance are now in place in all Great Lakes States. The States are currently issuing permits based on those standards. The Great Lakes Stales' work in this area has been exemplary and has positioned the Great Lakes to be a world class leader with regard to advancing water quality regulatory protection.

Key Objectives:

- By 2006, 100 percent of all NPDES permitted discharges to the Lakes or major tributaries will have permit limits that reflect the Guidance's water quality standards, where applicable.

Key Actions:

- USEPA will work with the States and eligible Tribes as they are beginning to incorporate the Guidance into their regulatory programs in order to help Stales and eligible Tribes identify and correct problems. USEPA will provide technical assistance, permit writing training, and other training courses.

ESTABLISHING TOTAL MAXIMUM DAILY LOADS

Under Section 303(d) of the Clean Water Act, States have listed, with Federal approval, portions of the Great Lakes and their tributaries as "impaired waters." These waters do not meet the approved State water quality standards even after permits or other pollution control requirements have been issued. The Clean Water Act requires that States and authorized Tribes address these impaired waters by developing a Total Maximum Daily Load (TMDL) determination which specifies the maximum amount of a specific pollutant that a waterbody can receive from multiple pathways, including stormwater runoff and air deposition, and still meet water quality standards (Including the GLI, where applicable).

Recent State actions have established priority rankings for impaired waters, including the Great Lakes and have scheduled TMDL development for these waters. The TMDL effort for each of the Great Lakes will be described in the TMDL Great Lakes Strategy, which will be discussed in the next LaMP update and closely linked to lakewide management planning. The development and use of Innovative approaches will also be considered in order to expedite the improvement of water quality and removal of impairments.

Key Objectives:

- By 2013, complete TMDLs for each Great Lake and Great Lake tributary listed on each State's 1998 303(d) list. Complete TMDLS for all waterbodies subsequently added to future 303(d) lists no later than 15 years after their first appearance on the list.

Key Actions:

- By 2002, include an update on the status of the Great Lakes TMDL Strategy in each of the LaMP updates.
- By 2004, USEPA, with assistance from States, will complete the Great Lakes TMDL Strategy, which will include EPA, States, and Tribal roles and responsibilities for completing TMDLs for the Great Lakes and their tributaries.

Continue to explore innovative or alternative approaches for developing TMDLs to address impaired waters and for implementing programs to restore these waters.

- USEPA will assist the States and Tribes in their development of TMDLs for waterbodies tributary to the Great Lakes by providing training, resources, guidance, and technical support as needed.
- The U.S. Geological Survey (USGS) will provide technical assistance to States, Tribes, and local agencies in developing TMDL5, including data and information on

Great Lakes tributaries, by undertaking in-depth studies with State and local agencies through the Cooperative Water-Resources Investigations Program.

ACHIEVING THE CHALLENGES OF THE GREAT LAKES BINATIONAL TOXICS STRATEGY

On April 7, 1997 the governments of Canada and the United States adopted the Great Lakes Binational Toxics Strategy (GLBTS) for the virtual elimination of persistent toxic substances in the Great Lakes, setting a precedent for cooperation between the two countries in the area of toxic reductions. For the first time, the United States and Canada acted together to establish specific, quantitative reduction targets for chemical substances. The GLBTS uses pollution prevention as the principal tool in achieving results.

Level! substances in the GLBTS Include PCBs, mercury, dioxins and furans, five bioaccumulative pesticides (chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene), octachlorostyrene, alkyl-lead, hexacblorobenzene, and benzo(a)pyrene. The GLBTS establishes reduction targets for the Level I Substances, and progress In meeting these targets is tracked. Management of Level II Substances, undertaken through pollution prevention activities and In compliance with the laws and policies, of each country, will be at the discretion of the various stakeholders of the GLBTS.

The GLBTS implementation emphasizes voluntary approaches and is carried out in a flexible, participatory, and action-oriented manner. Progress on GLBTS implementation is ongoing. During the first 3 years of implementation, under a mercury reduction challenge, the chlorine Industrial sector reduced consumption of mercury by 42 percent (on a production adjusted basis). A number of key partnerships have also been initiated with the health care sector and the iron and steel sector to explore other toxics reduction and pollution prevention opportunities.

Key Objectives:

By 2006, achieve all challenge goals of the GLBTS, making measurable and reportable progress, particularly:

- A 90 percent reduction nationally of high level PCBs (greater than 500 ppm) used in electrical equipment.
- A 50 percent reduction nationally in the deliberate use and a 50 percent reduction nationally in the release of mercury from sources resulting from human activity,
- A 75 percent reduction nationally in total releases of dioxins and furans from sources resulting from human activity.

Key Actions:

- By 2006, create ten additional voluntary partnerships with sources that use or release persistent toxic substances.
- Continue to initiate pesticide Clean Sweep programs in the Basin to promote the safe disposal and elimination of toxic substances.
- By 2003, investigate the contribution of backyard refuse burning to total releases of dioxins and furans and if appropriate, initiate State and local programs to provide affordable local alternatives to backyard refuse burning.
- By 2007, evaluate the implementation of the GLBTS and develop a process to renew commitments and challenges.

ADDRESSING IMPACTS FROM AIR DEPOSITION

Great Lakes researchers have collected a convincing amount of data demonstrating that toxic pollutants emitted into the atmosphere are being deposited directly into the Great Lakes, or deposited into inland ecosystems with subsequent transport to the Great Lakes by tributary flows and other processes. Furthermore, toxic air pollutants may be transported short or long distances from their original sources and some chemicals are transported atmospherically on a global scale. The Lake Michigan Mass Balance Study (LMMB), which focuses on four chemicals that are representative of classes of pollutants in the Great Lakes (PCBs, tramnonachlor, atrazine, and mercury), estimates that 1600 pounds of mercury and 3400 pounds of PCBs are deposited into Lake Michigan every year. Fish consumption advisories remain in effect in the Great Lakes for mercury, PCBs, and other pollutants, and atmospheric deposition is known to be a major contributor of these substances.

Under the Clean Air Act (CAA), USEPA has been working to reduce emissions of toxic pollutants through regulatory and non-regulatory methods. Under the Maximum Available Control Technology (MACF) program, IJSEPA Is using a performance-based approach to controlling toxic air pollutants. Since 1993, MACF standards

have been developed by USEPA for over 80 source categories, with additional source categories still under development[4].

State agencies and USEPA have also developed voluntary partnerships and agreements with facilities to reduce their toxics use, including steel mills, hospitals, schools, automobile manufacturers, dairy farms and dental offices.

In response to the mounting evidence of air deposition pollution to water bodies, Congress included the Great Waters program (section 112(m)) in the 1990 Clean Air Act Amendments. This program requires USEPA, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), to investigate the air deposition of toxic air pollutants to the Great Lakes and other water bodies by establishing sampling networks, investigating sources, assessing the contribution of air deposition to water quality violations, and determining if the current Clean Air Act provisions are sufficient to prevent serious adverse effects to public health and the environment.

Since 1990, the Integrated Atmospheric Deposition Network (IADN) has monitored deposition rates of priority air toxic pollutants to the Great Lakes. In addition, the eight Great Lakes States, the Province of Ontario and the Great Lakes Commission have developed the Great Lakes Regional Air Toxics Emissions Inventory and Regional Air Pollutant Inventory Development System (RAPIDS) to create the best available toxics emission estimates from all sources (point, area, and mobile) for regional modeling efforts.

Working together, USEPA, NOAA, States, and Tribes will continue to support efforts to monitor, characterize, model, and quantify emissions sources of toxics in the Great Lakes Region. We will work to reduce international emissions and support models that define the relationship between air pollutant sources and the effects of pollutants deposited on the Great Lakes. This information will guide regulatory and non-regulatory programs that work to eliminate the impacts of air toxic deposition and the risks of air toxics to both humans and the Great Lakes Ecosystem.

Key Objectives:

- Through the implementation of MACT standards promulgated in September 1997, achieve at least a 90 percent reduction in mercury and dioxin emissions from 1996 baselines from medical waste incinerators.

Key Actions:

- Implement the Clean Air Act provisions, including MACF standards, and commit to strong enforcement of these standards by USEPA and State Agencies.
- USEPA is committed to reducing emissions of mercury from coal-fired utilities through a nationwide cap and trade program. This program has been announced by the President and is currently under consideration by Congress.
- Adopt and implement emissions standards covering source categories accounting for 90 percent of the emissions of 30 identified urban air toxic pollutants.
- Establish national measures which enable Stale, Tribal, and local agencies to develop strong and flexible programs to reduce air toxics.
- Conduct periodic assessments of air quality, exposure and estimated risks from toxics for urban areas in the Great Lakes Region and provide information to the public.
- The State of Wisconsin will propose regulations to reduce atmospheric mercury emissions from major electric utilities by 90 percent within iS years after promulgation.
- Consistent with its statutory goal, Minnesota will reduce statewide mercury releases to air by at least 70 percent by 2005, compared to 1990 levels.
- Support the expansion of State and tribal monitoring efforts related to air toxic deposition, particularly for PBTs which support legislation and policy efforts. Support the efforts of Tribes in the Great Lakes Basin in the development of Tribal Implementation Plans (TIPs) to address adverse environmental impacts resulting from air deposition.
- Integrate IADN with new regional, national, and international monitoring efforts and report on the deposition of PBTs. Add mercury deposition monitoring to at least one U.S. IADN station and evaluate the feasibility and cost of adding additional chemicals of concern to the network, as appropriate. Evaluate the expansion of the IADN network to include new urban sites in order to determine urban sources and evaluate current and future regulations.

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[4]Regulations for large municipal waste combustors that have recently been fully implemented and regulations for medical waste and small municipal waste incinerators that will be implemented in 2002 and 2005, respectively, will greatly reduce mercury and dioxin emissions from these sources.

- Expand and improve the Great Lakes Regional Air Toxics Emissions Inventory, and RAPIDS to support analyses of emission trends. Make special efforts to focus on PBTs of concern to the Great Lakes including an in-depth quality assurance effort.
- Study the relationship between the Great Lakes Regional Air Toxics Emissions Inventory and atmospheric deposition monitoring data. Work to better understand source/receptor relationships and improve inventory and modeling techniques to better characterize emissions and forecast deposition, and support future efforts to resolve these issues.
- Promote the Urban Air Toxics Strategy on the Federal, State, and Tribal level. Commit to further defining air toxics risks to the Great Lakes Basin's residents and ecosystems by conducting multi-pathway risk studies and community assessments. Assure that the residual risk (112(1)) program addresses atmospheric deposition concerns of PBTs, including evaluation of emissions, impacts, and multiple exposure pathways.

ACHIEVING OUT-OF-BASIN TOXICS REDUCTIONS

A major challenge for the Great Lakes is to address persistent toxic pollutants on a national, international, and global scale. These pollutants easily transfer among air, land and water and travel across vast geographic boundaries. Recognizing the need to achieve out-of-basin toxics reductions, the GLBTS is closely coordinated with other domestic and international programs. The national multi-media PBT Program is focused on reductions for the same set of pollutants, and the efforts of the GLBTS chemical-specific workgroups have supported the development of the PBT Program national action plans. The GLBTS also is coordinated with USEPA's Office of International Affairs to support international efforts, such as the Persistent Organic Pollutants and Heavy Metals Protocols under the United Nations' Economic Commission for Europe's Convention (UNECE) on Long Range Transboundary Air Pollution (LRTAP)P the Stockholm Convention on Persistent Organic Pollutants, and the North American Commission for Environmental Cooperation (CEC) Sound Management of Chemicals Program. Under the latter program, North American Regional Action Plans (NARAPs) have been developed for a number of chemicals. These efforts work toward international voluntary activities and legally binding agreements resulting in reductions of persistent toxic substances.

Key Actions:

Continue to support and coordinate with national initiatives that will reduce or eliminate out-of-basin inputs of toxics to the Great Lakes, including the PBT Program.

Work within international forums to reduce air toxics from sources outside the Great Lakes Basin. Actively participate in international efforts which focus on air toxic reductions such as the 1998 Persistent Organic Pollutants Protocol of the UNECE LRTAP Convention and the CEC Sound Management of Chemicals Program. Support actions in the CEC's NARAP for mercury.

CLEANING UP PAST CONTAMINATION: SEDIMENTS

Due to the highly industrialized nature of many harbors and tributaries on the Great Lakes, these areas have historically received inputs of chemical pollutants which have concentrated in the bottom sediments. Although discharges of persistent toxic substances to the Great Lakes have been reduced in the last three decades, high concentrations of contaminants remaining in the bottom sediments of many rivers and harbors have raised considerable concern about risks to aquatic organisms, wildlife and humans. Exposure to contaminated sediment may impact aquatic life through the development of cancerous tumors, loss of suitable habitat, and toxicity to fish and benthic organisms. Exposure also impacts wildlife and human health by the bioaccumulation of toxic substances through the food chain. Contaminated sediments are one of the major causes of fish consumption advisories that are in place at many locations around the Great Lakes. There are economic consequences to contaminated sediments as well. They can prevent or delay the dredging in navigational channels and recreational ports, require additional costs for removal and management, and impose other costs to waterborne commerce and local recreational economies.

Annexes 14 (Contaminated Sediments) and 2 (Remedial Action Plans) of the GLWQA focus on specific activities that should be undertaken to address Beneficial Use Impairments related to contaminated sediments. In addition, the GLBTS calls for action to address PBTs present in Great Lakes sediment.. The Great Lakes agencies have completed or are currently addressing the remediation of over three

million cubic yards of contaminated sediments in the Basin, at an estimated cost of Over two hundred million dollars. These actions are principally within the AOCs. Unfortunately, this work represents only a fraction of the total effort necessary to fully remediate contaminated sediments in the Great Lakes. Progress in cleaning up contaminated sediments and restoring the associated beneficial uses has been slow since the GLWQA was signed and only one of the 43 AOCs has been delisted to date (Collingwood Harbour, Ontario, Canada).

The International Joint Commission's Water Quality Board prepared a document in 1997 entitled, "Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin." The UC report summarized major obstacles to sediment remediation, and grouped them into the following six categories: limited funding and resources; regulatory complexity; lack of a decisionmaking framework; limited corporate involvement; insufficient research and technology development; and limited public and local support. Successfully addressing the contaminated sediment problem will necessitate overcoming these obstacles.

In recent years, Congress has enacted legislation giving the U.S. Army Corps of Engineers (USACE) authority to support States, local governments, and Tribes responsible for addressing contaminated sediment problems including: 1) technical support for Remedial Action Planning, 2) removal and remediation of contaminated sediments from areas outside Federal navigation channels, and 3) development and demonstration of promising remediation technologies.

Federal, State, and Tribal regulatory and trustee agencies will continue to address contaminated sediments through their respective enforcement authorities[5] and also through innovative approaches and Federal/State/private partnerships. These agencies will coordinate complementary Federal and State authorities, to leverage government and private resources to address the contaminated sediment problem and its sources.

Key Objectives:

- Accelerate the pace of contaminated sediment remediation, working to overcome barriers to progress identified at each site. Bring together complementary Federal and State authorities, and/or government and private resources to address the contaminated sediment problem and its source, so that:

BEGINNING IN 2002, INITIATE THREE REMEDIAL ACTION STARTS EACH YEAR.

- Beginning in 2004, complete three sediment remedial actions per year until all known sites in the Basin are addressed.
- Complete the cleanup of all known sites in the Basin by 2025.

Key Actions:

- Restore the beneficial uses impaired by sediment contamination in AOCs, as a critical step toward their delisting. Monitor before, during, and after sediment remediation assess and document remedy effectiveness.
- Beginning in 2002, track and report on an annual basis the number of sediment remediation project starts and completions in the Great Lakes.
- By 2004, each State member of the U.S. Policy Committee, working with USEPA, USACE, NOAA, and the U.S. Fish and Wildlife Service (USFWS), will develop an integrated list of sites for remedial and restoration activities, with estimated costs and schedules. These lists will be updated biennially. USEPA will maintain this comprehensive list of known contaminated sediment sites in the Great Lakes, including, but not limited to AOCs, that will help to inform the Great Lakes community On the location and magnitude of remaining sediment contamination that could require remedial and restoration actions.
- Develop and implement a collaborative outreach strategy to promote greater public awareness of contaminated sediments issues and enhance public involvement in the remedial decisionmaking process early and often.
- Engage in a dialog with regional industrial and manufacturing groups to promote greater corporate participation in contaminated sediment remediation.

PROMOTING THE SAFE CONSUMPTION OF GREAT LAKES FISH AND WILDLIFE

Many North Americans enjoy fishing and hunting in the Great Lakes Basin, and many residents earn their livelihood from these activities. Unfortunately, a variety of persistent toxic substances circulate within the Great Lakes environment and bio-

[5] Including the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), Resource Conservation and Recovery Act (RCRA), Clean Water Act (CWA), Toxic Substances Control Act (TSCA), and the Oil Pollution Act (OPA).

accumulate in animal tissues. Several studies of Great Lakes fish consumers have shown that long-term exposures can cause chronic health effects and pose a special risk to fetuses, children, women of child-bearing age, and those who extensively fish for food. Contaminant levels and resulting exposures due to wildlife consumption have received less intensive study.

The use of consumption advisories is an interim measure to reduce exposure by promoting the safe consumption of fish and wildlife. All the Great Lakes and their connecting channels are currently under a fish advisory, mainly due to PCBs, although dioxin and chlordane also cause advisories. In addition, several States have State-wide mercury, advisories for their inland waters. Unfortunately, surveys have revealed that a large portion of the subsistence and sport fish consuming public is unaware of these advisories.

Based on our current understanding of how these chemicals circulate in the environment, It Is expected that advisories will be in place for several decades. However, cleaning up contaminated sediments and reducing new loadings of toxic substances would significantly shorten this timeframe. There is also a concern that Invasive species can potentially redistribute pollutants in the food web. The long-term goal is to ensure that all Great Lakes fish and wildlife are safe to eat without restriction.

Key Objectives:

- Implement actions Identified throughout this Strategy, particularly, in the Contaminated Sediments and Air Deposition sections, to reduce exposure to toxic substances from the consumption of contaminated fish and wildlife. As an indicator of progress toward the reduction of toxic substances in native, top-level predators, concentrations of PCBs in whole lake trout and walleye samples will decline by 25 percent in the period from 2000 to 2007.

Key Actions:

- ATSDR, State health and environmental agencies, Tribes, and USEPA will continue to improve their understanding of exposure and health risks associated with the consumption of contaminated fish and wildlife. Enhanced communications will be provided to the public, including at-risk populations, about the importance of following existing fish and wildlife advisories.

USEPA will report every 2 years on concentrations of key pollutants (PCBs, chlordane, and mercury) in coho and chinook fillets, as well as whole lake trout and walleye. Consideration will be given to monitoring and reporting of other chemicals of potential health concern, such as chlorinated napthalenes, polybrominated diphenyl ethers, and toxaphene, as part of a long term trend monitoring program.

- Evaluate the result of surveys sponsored by ATSDR, States, USEPA, Tribes, and academic institutions on the effectiveness of fish advisories and develop improved systems for communicating information to high-risk communities, including non-English speaking minorities and sensitive populations.
- ATSDR, USEPA, State and Tribal health agencies will pursue further research in the area of mercury exposure from fish and wildlife consumption.
- Federal, State, and Tribes will support the work of the LaMPs and any Great Lakes human health committees by providing information on contaminants and fish and wildlife consumption advisories.
- Federal, State, and Tribes will provide data from their fish tissue sampling programs to the Great Lakes Fishery Commission for inclusion in the Commission's State of the Lake reports, which are issued on a rotating basis for each Lake every 5 years.
- States, USEPA, and Tribes will explore contaminant levels and exposures from the consumption of wildlife and native foods.

MAINTAINING A HEALTHY NUTRIENT BALANCE

Phosphorus is an essential element for all organisms and is often the limiting factor for aquatic plant growth In the Great Lakes. Although phosphorus is found naturally in tributaries and run-off waters, the historical problems caused by elevated levels have predominately originated from human-made sources. Sewage treatment plant effluent, agricultural run-off, and industrial processes have released large amounts of phosphorus into the Lakes.

Strong efforts that began in the 1970's to reduce phosphorus loadings have been successful in also reducing nutrient concentrations in the Lakes, although high concentrations still occur locally in some bays and harbors. Phosphorus loads have decreased in part due to changes in agricultural practices (e.g., conservation tillage and integrated crop management), use of non-phosphorus detergents, and improvements made to sewage treatment plants and sewer systems.

Our overall approach is to ensure that Great Lakes waters shall be free from nutrients, directly or indirectly entering, the waters as a result of human activity, in amounts that create growths of aquatic life that interfere with beneficial uses.

Key Actions:

- Continue to monitor phosphorus concentrations closely to ensure nutrient levels can Support desired fish community structures and populations.
- Continue to support the implementation of rural and urban nutrient management practices under Section 319 of the CWA and Section 6217 of the Coastal Zone Management Act (CZMA).
- Construct and test models of nutrient cycling in each of the Great Lakes to account for the role now played by zebra mussels.
- Assess the capacity and operation of existing sewage treatment plants in the context of increasing human populations being served to determine if additional upgrades in construction or operations may be' required.
- In cooperation with participating State, Tribal, and Federal agencies, USGS will continue to collect streamflow data, and, in selected areas, water-quality and ancillary data to support the calculation of annual tributary loadings to the Lakes.

PHYSICAL INTEGRITY: PROMOTING HABITAT PROTECTION, WATER QUANTITY MANAGEMENT AND IMPROVED LAND USE PRACTICES

Goal: Protect and restore the physical integrity of the Great Lakes, supporting habitats of healthy and diverse communities of plants, fish, and other aquatic life, and wildlife in the Great Lakes Basin Ecosystem. Protect Great Lakes water as a regional natural resource from non-sustainable diversions and exports, and promote improved land use practices.

The Great Lakes Basin is a unique Ecosystem, containing many ecologically rich areas and diverse community types, including terrestrial forests, dunes, prairie, savannah, barrens, wetlands, alvars, islands, and aquatic habitat. These areas, many of which are at risk of being lost or degraded, provide essential habitat for important native biota and rare species. Numerous stressors threaten the physical integrity of the Great Lakes Basin Ecosystem, as discussed in more detail below.

HABITAT PROTECTION AND RESTORATION

Risks to habitat in the Great Lakes Basin include sprawl and the loss of greenspace, invasive species, hydrological alterations, shoreline hardening, incompatible land uses, and the problems of urbanization and pollution. The long-term restoration and protection of the Great Lakes Ecosystem requires the cooperation of a wide variety of partners, including non-governmental organizations, private landowners, industry, and government, because many of these issues' cut across traditional political and organizational boundaries. Several ongoing multi-partner programs comprise the primary tools for prioritizing and coordinating Great Lakes habitat protection, including the State of the Lakes Ecosystem Conference (SOLEC), LaMPs, and RAPs, which continue to identify ecologically rich areas for protection and restoration. Through the SOLEC process, "Biodiversity Investment Areas" have been identified in the Great Lakes Basin to assist local land use jurisdictions as they develop protection and restoration plans. Lake-specific habitat work is coordinated through the LaMPs, and local habitat restoration is taking place through the RAP process at AOCs.

All Federal agencies have a mandate to conserve Federal endangered and threatened species under Section 7(a)(1) of the Endangered Species Act. Several Federal and State agencies are conducting ongoing analyses to identify important habitat for protection and restoration. "Critical Ecosystems" are being identified in the Basin by a variety of partners. The Fish and Wildlife Service's Coastal Program and, through NOAA's Coastal Zone Management (CZM) Program, State coastal management programs provide grants for State, Tribal and local initiatives such as: biological inventories, site management plans, greenways, ecological corridors, on-the-ground restorations, and site conservation plans. NOAA's National Strategy to Restore Coastal Habitat continues to direct restoration and protection activities. USEPA supports support habitat improvement practices, including construction and enhancement of coastal wetland systems, under Section 319 of the Clean Water Act. The USGS, USFWS, and Tribes are involved in mapping fish spawning grounds. Some States are preparing "biodiversity management plans" and mapping fish spawning grounds as well.

In addition, non-governmental organizations (NGO's) are identifying "priority conservation areas," "potential wilderness areas," "American Heritage Rivers,' "biodiversity hotspots," "important bird areas' and preparing many other recommenda-

tions for protecting or restoring high priority natural areas. Most of these efforts are ongoing, and this short list is far from complete.

Recognizing the particular vulnerability of coastal habitat, this Strategy focuses on its protection and restoration as a first priority, with a special focus on coastal wetlands, a unique and limited resource. It also recognizes and addresses the long-term need to protect and restore habitat throughout the entire Great Lakes Basin.

Key Objectives:

With the philosophy of no net loss, continue to fulfill Federal, State, and Tribal management responsibilities for the estimated 10 million acres of coastal and inland wetlands on the United States side of the Basin.

By 2005, support the restoration of fish and wildlife habitats by developing partnerships with Federal, States, Tribes, and private interests to construct habitats by beneficially using dredged material at six sites.

By 2005, support the Great Lakes Fishery Commission, Tribes and others in the control and management of sea lampreys by constructing 20 sea lamprey barriers on tributaries to the Great Lakes, taking into account effects on fish populations.

By 2005, support the restoration of aquatic habitats by developing partnerships between Federal and State agencies to dredge contaminated sediments at five locations, using existing non-regulatory Federal, State, and Tribal programs.

By 2007, support the restoration of the Great Lakes fishery by developing partnerships with Federal, State, and private interests to construct 20 wetlands, using existing non-regulatory Federal, State, and Tribal programs.

By 2007 restore and protect coastal bald eagle habitat to allow the recovery of eagle populations and achieve a 10 percent increase, relative to the year 2000, in the number of occupied territories that produce at least one young per year in coastal habitat.

By 2010, restore, enhance, or rehabilitate 100.000 acres of coastal and inland wetlands in the Great Lakes Basin, using existing Federal, State, and Tribal programs[6].

Key Actions:

- By 2002, USFWS's Great Lakes Basin Ecosystem Team wiliprioritize and coordinate conservation efforts for Great Lakes islands and lake sturgeon habitat.
- The USGS, through its GAP Analysis Program, wiil work with State and Tribal natural resource and wildlife agencies to identify conservation priorities for preservation and restoration of terrestrial and aquatic biodiversity in the Great Lakes Region.
- By 2002,the: USACE, with the Great Lakes Fishery Commission and the signatories to A Joint Strategic Plan for The Management of The Great Lakes Fisheries, will complete the support plan for Great Lakes Fishery and Ecosystem Restoration Program.
- By 2003, collect the lists, descriptions, and maps of the high quality ecosystems that have been identified by the great variety of partners in the Great Lakes Basin. By 2004, develop selection criteria and compare the various high quality ecosystems from all of the partners and make recommendations to the USPC about which sites are of greatest interest.
- Ensure that management plans for publicly owned land in the Great Lakes Basin address the critical species, natural communities, and ecosystems that are representative of Great Lakes Basin biodiversity.
- Promote native species and plantings in contiguous watershed environments through Conservation Districts and Drain Commissions.
- By 2005, identify a continuum of stopover sites for migratory birds that pass through the Great Lakes Region, and critical areas in need of restoration and/or protection.
- By 2005, establish projects in coastal National Parks or National Wildlife Refuges in the Great Lakes Basin as demonstrationsites for successful invasive species eradication and control, as well as habitat restoration, on public lands.

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[6] This goal will be achieved primarily through non-regulatory programs (e.g., USDA's Wetland Reserve Programs and Emergency Wetlands Reserve Program, USFWS' Partners for Fish and Wildlife, various State programs, etc.). USACOE's Section 404 regulatory program is designed to ensure no net loss of wetlands from projects involving the discharge of dredge or till material to waters. Due to site-specific factors affecting mitigation projects, (e.g., timing, probability of success, differing ecological values and functions), Section 404 permits sometimes require greater than one-for-one mitigation of last wetland acreage. In such cases, additional wetlands that are created, restored, or enhanced may be counted toward this goal.

• States' Coastal Zone Management Programs, in partnership with NOAA, will continue to inventory and designate areas of special coastal-related value, including Areas of Particular Concern and Areas for Restoration and Preservation.

SPECIAL FOCUS AREA: GREAT LAKES COASTAL WETLANDS

The Great Lakes coastal zone includes the relatively warm and shallow waters near the shore, coastal wetlands, and the land areas directly affected by lake. processes. These areas are the most diverse and productive parts of the Great Lakes ecosystem. Great Lakes coastal wetlands play a pivotal role in the aquatic ecosystem of the Great Lakes, storing and cycling nutrients and organic material from the land into the aquatic food web. Most of the Lakes' fish species depend upon them for some portion of their life cycles. Large populations of migratory birds rely on them for staging and feeding areas. Coastal areas also receive some of the most intense human activity. As a result, the areas that contain the greatest biological resources are subject to the greatest stress.

Two important tools in coastal wetland protection are NOAA' s CZM Program and the SOLEC Indicators Initiative. Under the CZM Program, NOAA, and the States select enhancement areas for funding to protect, restore, or enhance the existing coastal wetlands base or to create new coastal wetlands. Participants in the SOLEC Indicators Initiative have identified coastal wetlands as a special focus area, and the Great Lakes Coastal Wetland Consortium will develop basin-wide monitoring methods for these important habitats.

Key Actions:

• Federal, State, and Tribal agencies will continue to participate in the Great Lakes Coastal Wetlands Consortium, initiated in early 2000.

• By 2003, the Great Lakes Coastal Wetland Consortium will create and populate a binational GIS data base on Great Lakes coastal wetlands accessible to all scientists, decisionmakers, and the public. This data base will contain data on the location and classification of coastal wetlands and data on indicators of wetland quality.

• By 2003, the Great Lakes Coastal Wetland Consortium will design and establish a program for monitoring the quality of international Great Lakes coastal wetlands. In addition, It will identify and rank major threats to coastal wetlands (e.g., development, invasive species, hydrological alteration, resource extraction, shoreline hardening, etc.).

PROTECTION OF GREAT LAKES WATER RESOURCES

Over the past few years, the diversion of water from the Great Lakes Basin has become a high profile issue, both nationally and internationally, most notably centered on a Canadian company's 1998 proposal to export Lake Superior water to markets overseas. Throughout the Basin, numerous concerns were voiced over the lack of any consultation or analysis of the environmental implications of such a withdrawal. The request was subsequently withdrawn. This situation brought the issue of water diversion to the top of the Great Lakes agenda.

In accordance with Section 504 of the 2000 amendments to the Water Resource Development Act (WRDA), the Great Lakes Governors have led the development of a stronger regional water management system. Under WRDA, no bulk export or diversions from the Basin can take place without the unanimous approval of all Great Lakes Governors. Recently, the Great Lakes Governors and Premiers have committed to developing conservation and restoration-based standards for reviewing proposed withdrawals. The long-term goal is to manage Great Lakes water resources in a manner which will protect and sustain the Great Lakes Ecosystem, while also maintaining a strong economy.

Groundwater is the source of drinking water for about 8.2 million people within the Great Lakes Watershed. Recent publications, including USGS's report The Importance of Groundwater in the Great Lakes Region, have increased public awareness of groundwater resources. Besides providing drinking water, this important natural resource is a large, subsurface reservoir that slowly releases water to provide reliable stream water flow and helps ensure habitat for aquatic animals and plants during periods of low precipitation. This resource needs to be characterized according to its availability, quality, and demand to develop a sustainable supply for all uses.

Key Actions:

• Support the efforts of the Great Lakes Governors and Premiers, as articulated in "Annex 2001", to prepare a binding agreement within 3 years, with broad public

participation, on conservation and restoration-based standards for withdrawals of Great Lakes water.

- Protect Great Lakes groundwater resources through existing multi-agency groundwater protection programs. Increase understanding of the linkage between the watershed, groundwater, and the Great Lakes.
- Support the work of the Central Great Lakes. Geologic Mapping Coalition whose purpose is to map and characterize glacial and related deposits in three dimensions, from the land surface all the way down to and including the underlying bedrock, so that groundwater can be carefully managed and protected.
- NOAA and States will continue to implement the CZM Program, including elements which address policies regulating water withdrawals within their boundaries.
- USGS will continue to compile information on water use at 5-year intervals for the Great Lakes Basin as part of the National Water Use Program.

USGS will continue to develop an increased understanding of the role of groundwater in the Great Lakes through the projects supported by the National Ground-Water Resources Program National Water-Quality Assessment Program, and in cooperation with the State geologists and State geologic mapping programs through the Central Great Lakes Geologic Mapping Coalition.

SUSTAINABLE LAND USE

In communities across the Great Lakes Region, there is a growing concern that current sprawling development patterns are. not in the long-term interest of the existing suburbs, small towns, inner cities, rural communities, or wilderness areas in the Basin. The cost of abandoned infrastructure in the city; loss of open space and prime agricultural lands at the suburban fringe, and longer vehicle commuting times with attendant increases in air pollution, all impact on the environmental health and overall quality of life in the Great Lakes Basin. These concerns have spurred a national "Smart Growth" movement.

The principles of Smart Growth include the preservation of open spaces, farmland, natural beauty, historic buildings, and critical environmental areas; reinvestment in and strengthening of existing communities; fostering distinctive, attractive communities with a strong sense of place; maintaining local authority for planning and managing growth while recognizing the need for regional perspectives and cooperation; providing a variety of transportation choices; providing incentives for collaboration among local governments; and partnerships among local, Tribal, State, and Federal levels of government; and encouraging revenue policies that promote balanced growth decisions. There are a wide variety of stakeholders in the Smart Growth movement including environmentalists and community activists, community development organizations; real estate developers; planners; Federal, State, Tribal, and local government officials; lending institutions, and architects.

Great Lakes States have been leaders in pioneering innovative Smart Growth legislation. Examples Include Wisconsin's Comprehensive Planning Grant programs, and Pennsylvania's $650 million "Growing Greener" investment, "Growing Smarter" land-use reforms, and nationally known Land Recycling Program. In 1996, the USEPA and NOAA joined with several non-profit and government organizations to form the Smart Growth Network. The Smart Growth Network (SON) works to encourage development that serves the economy, community, and the environment. The Network provides a forum for:

- Raising public awareness of Smart Growth and the implications of development decisions for the economy, community, and the environment;
- Promoting Smart Growth best practices through educational publications and other venues;
- Developing and sharing information, innovative policies, tools, and ideas;
- Fostering collaboration, among Network partners and members who represent various interests, to apply Smart Growth approaches to resolve problems of the built environment; and,
- Cultivating strategies to address barriers to, and to advance opportunities for, Smart Growth.

Other relevant activities Include the implementation of State Coastal Nonpoint Pollution Control Programs developed pursuant to section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). This program provides for the implementation of management measures for site development designed to protect sensitive areas, limit increases in impervious cover, and limit land disturbance activities. Also, the Nonpoint Education for Municipal Officials Program (NEMO) supports improved land use decisionmaking by educating local officials on the principles of natural resource based planning.

Key Actions:

- Continue to participate in and support the Smart Growth Network.
- Continue to implement State Coastal Nonpoint Pollution Control Programs.

BROWNFIELD REDEVELOPMENT

A key component of Smart Growth is brownfields redevelopment. A Brownfield is a site that has actual or perceived contamination, as well as an active potential for redevelopment or reuse, It is estimated that there could be as many as 100,000 such sites in the Great Lake States, many of which are in the Basin. Because lenders, investors, and developers fear that involvement with these sites may make them liable for cleaning up contamination they did not create, they are more attracted to developing new sites in pristine areas, or "greenfields."

USEPA's Brownfields Economic Redevelopment Initiative is designed to empower States, Tribes, communities, and other stakeholders to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse Brownfields. Through this initiative, over 20 agencies have worked in partnership to coordinate Federal programs related to Brownfields redevelopment. The centerpiece of this national partnership has been the designation of Brownfield Showcase Communities to serve as models for community-based cleanup and redevelopment. USEPA's Superfund Redevelopment Initiative similarly helps communities return Superfund sites to productive use. Great Lakes States have also taken a leadership role in Brownfields redevelopment. For example, in FY1998, Michigan passed the Clean. Michigan Initiative bond, a $650mlllion program focused on cleaning up Brownfields and greenspace preservation. Similarly, in FY2000, the State of Ohio passed Issue 1, a $400 million program also aimed at Brownfields restoration and farmland preservation. All Great Lakes States also have voluntary cleanup programs, by which many of the Brownfield sites are remediated.

Key Actions:

- USEPA, Federal, State, and Tribal agencies will continue to support local Brownfield redevelopment efforts through funding and Implementation of:
- Site assessment, job training, cleanup revolving loan funds, and showcase community pilot programs, Federal tax incentives for Brownfield redevelopment, and programs which fund site pre-development and infrastructure needs, including transportation, demolition, and other necessary activities to revitalize sites.
- State voluntary cleanup programs and Brownfield programs that provide technical assistance to local Brownfield practitioners, and various financial incentives for redevelopment.
- Interagency and interjurisdictional partnerships such as the Brownfields National Partnership and Brownfield Showcase Communities.
- Technical assistance such as the field services from USACE, USGS, and State Geological Surveys.

PROMOTING CONSERVATION PRACTICES ON AGRICULTURAL LANDS

Based on State analyses (305(b) reports), a leading cause of water quality impairment in the Great Lakes Basin is contaminated runoff, and agriculture is one of the most extensive source of this pollution. Continuing efforts over the last several years have promoted the reduction of pesticide and nutrient run-off through improved agricultural practices such as conservation tillage, no-till planting, and the use of buffer strips, while also addressing more recent problems that can occur from mismanagement of large-scale animal production farms.

Practices such as conservation tillage and no-till planting have proven effective in reducing erosion on agricultural lands. Conservation tillage is rapidly becoming the primary cultivation practice in the Basin, affecting as much as 70 percent of the total acreage in many counties, and 48 percent basin wide. Buffer strips, vegetation established between fields' and surface waters, also help reduce sediment, nutrients, and chemicals entering tributaries that flow into the Great Lakes. Innovative programs, such as USDA's Conservation Reserve Program (CRP), National Conservation Buffer Initiative, and the Environment Quality Incentive Program (EQIP), provide a systems approach for addressing agricultural non-point source pollution to the Great Lakes. The Federal Farmland Protection Program, administered by the NRCS, supports matching grants and non governmental organizations to purchase conservation easements on agricultural lands. NRCS also supports the Great Lakes Commission's Great Lakes Basin Program for soil erosion and sediment control.

Through the CZMA, State coastal management programs coordinate, promote, and implement State efforts to address nonpoint sources of pollution. In addition, USEPA has several. standing programs to address soil erosion and sedimentation

within the Basin. Local conservation districts also play a key role in enhancing efforts to establish conservation buffers and no-till planting methods. Together, these efforts help sustain the production of food and fiber products while maintaining environmental quality and a strong natural resource base.

Thirty-eight percent of the Nation's 450,000 animal feeding operations exist in the Midwest, and the many of these are in the Great Lakes Basin. In 1999, the USDA and the USEPA issued a Unified National Strategy for Animal Feeding Operations (UNSAFO) to minimize the water quality and public health impacts of livestock operations. Two important steps in the Strategy were the recently proposed regulations to address water pollution from concentrated animal feeding operations and the voluntary development of Comprehensive Nutrient Management Plans (CNMP). The USEPA and USDA, in coordination with the States, have sought public comment, and will revise' and implement this regulation and planning effort.

Key Objectives:

- Consistent with the goals of the National Conservation Buffer Initiative, establish 300,000 acres of buffers in the Great Lakes Basin by 2007 (base year 1999), using existing, non-regulatory Federal and State programs, and track this progress under USDA's CRP.
- In accordance with the Unified National Strategy for Animal Feeding Operations, assist and track the development of CNMP for Animal Feeding Operations in the Great Lakes Basin by 2009. The continued technical and financial support provided under the UNSAFO and EQIP will be necessary to complete this goal.

Key Actions:

- USDA will continue to implement CRP and will work with any State's effort to supplement the CRP funding with a Conservation Reserve Enhancement Program targeted to the Great Lakes Basin. The development of forested riparian areas in the northern Great Lakes Basin will also be promoted as a means to support cold water fisheries.
- Encourage and support the National Association of Conservation Districts' Great Lakes Buffer/No-Till Program, which will help protect and enhance water quality in the Great Lakes and the tributaries that flow into the Lakes.
- USEPA will work with States to issue NPDES permits to concentrated animal feeding operations, or implement functionally equivalent approaches as per the Unified National Strategy for Animal Feeding Operations, Strategic Issue #3, or future Federal guidance or rules.
- Continue to support the implementation of rural and urban nutrient conservation practices by the States under Section 319 of the CWA and Section 6217 of the CZMA.
- By 2013, implement the CZARA management measures for facility wastewater and runoff from confined animal facility management.

OVERFLOWS FROM SANITARY SEWERS AND COMBINED SEWER SYSTEMS

During heavy wet weather events, sewer systems can be overwhelmed by, high flows, resulting in the release of raw sewage from combined sewer overflows (CSO) and sanitary sewer overflows (SSO). Combined sewers, systems designed to collect both storm water and sanitary wastewater, can overflow when the capacity of the wastewater treatment facility is exceeded or when flows exceed the capacity of sections of the transport system. Separate sanitary sewer systems can also experience untreated discharges related to wet weather events. These can be caused by excessive inflow and infiltration, inadequate maintenance, and insufficient wet weather transport capacity. SSOs and untreated CSOs can contain pathogens that lead to beach closures and human health concerns, as well as oxygen demanding substances that can lead to low dissolved oxygen levels. Untreated CSOs discharges may also contain industrial pollutants.

USEPA's CSO Control Policy outlines approaches for addressing CSOs in order to achieve the requirements of the Clean Water Act. States have also adopted policies, strategies and rules consistent with the National CSO Policy, and use these as a basis for issuing permits and compliance orders for CSO control. CSO communities are required to develop and implement interim controls and long term control plans for assuring that CSOs do not cause or contribute to violations of water quality standards.

Avoidable SSO discharges can lead to enforcement actions by States or USEPA. USEPA is developing an SSO policy to help prevent avoidable SSOs and mitigate the impacts of those which are unavoidable.

Key Objectives:

- By 2005 100 percent of all CSO permits in the Great Lakes basin will be consistent with the national CSO Pohcy. All issued/reissued permits for CSO discharges will contain conditions that conform to the National CSO policy, and Sates will prioritize the reissuance of CSO permits under their permit backlog strategies.'
- By 2010, all sewer systems will be operated under long-term Comprehensive management plans which will optimize performance and minimize discharges from SSOs.

Key Actions:

- Prioritize wet weather program activities to focus on CSO and SSO discharges impacting bathing beaches and other areas of potential health risk exposure in the Great Lakes Basin.
- By 2003, USEPA and States will assist local governments in establishing alternate funding vehicles to implement CSO/SSO abatement construction projects.

STORM WATER DISCHARGES

With increasing urban growth, storm water discharges are a growing concern in the Great Lakes. After heavy rains or snowmelt, pollutants from lawns, streets, parking lots, constructionsites, and industrial or commercial areas are collected in storm drains and transported directly to nearby waters without treatment. Illicit discharges and discharges from failing septic systems can also find their way to storm drains. "Phase I" storm water regulations currently require permits for storm water discharges from industrial sites, construction activities disturbing five acres of land, and larger municipal separate storm sewer systems ("MS4's"). Phase LI regulations will require NPDES permits for constructionsites' disturbing one acre or greater and from most MS4's in urbanized areas. The focus of the permit requirements is to develop and implement best management practices to control pollutants in storm water. Phase II permits must be effective by March 2003. USEPA and the Great Lakes States are working together to reduce the threat of wet weather discharges to water quality, while reducing pollution control costs. Other relevant activities include the implementation of management measures for new development under CZARA.

Key Objective:

- By December 31, 2003, storm water permits will be in place for all phase II storm water discharges (small construction and small MS4's), unless States choose to phase in permit coverage on a watershed basis.

BIOLOGICAL INTEGRITY: PROTECTING HUMAN HEALTH AND THE ECOSYSTEM'S SPECIES

Goal: To protect human health and restore and maintain stable, diverse, and self-sustaining populations of plants, fish and other aquatic life, and wildlife in the Great Lakes Ecosystem.

Our first two goals—reducing toxic pollution and protecting habitats—will improve the fundamental capacity of the Great Lakes Ecosystem to sustain life. This goal addresses other actions needed to protect human health and the health of other species in the Ecosystem. The public requires safe drinking water and clean beaches, as well as clear warnings about periods when these resources may be compromised, to ensure their well-being. Other species that share this Ecosystem need to be protected from human activities, such as the introduction of new non-indigenous invasive species. The following actions are needed to ensure our continuing enjoyment of a11 these resources.

HUMAN HEALTH STUDIES

The Agency for Toxic Substances and Disease Registry (ATSDR) Great Lakes Human Health Effects Research Program (GLHHERP) has made significant progress in evaluating and reporting the findings that address public health issues from exposure ,to contaminants in the Basin. The program has been proactive in initiating risk communication and public health intervention strategies in sensitive populations to reduce their exposure to persistent toxic substances. Continued support of our Great Lakes research program is vita] to the success of the overall research effort in the Basin and our capacity to' address key human health research gaps in the years ahead. Conclusions and finding from these studies will be assessed and will support management actions and research plans.

Key Action:

- Continue human health studies under the Great Lakes Human Health Effects Research Program, and make results available to environmental managers and the public.

MAINTAINING THE GREAT LAKES AS A SAFE SOURCE OF DRINKING WATER

The Great Lakes have been, and continue to be, an abundant and high quality source of drinking water for millions of people. We must assure that the Great Lakes continue to provide a safe source of drinking water for residents of the Basin. We will work together to carry out several initiatives that will assist us in meeting this goal.

The SOLEC and the American Water Works Association will undertake a joint binational effort to assess the quality of water at 22 drinking water treatment plants around the Lakes. These plants will monitor raw water for parameters such as Total Organic Carbon (TOC), turbidity, and microbial indicators. Measurement of these parameters over time at the U.S. locations will provide a useful snapshot of the untreated water as it enters the drinking water treatment system.

Under the Safe Drinking Water Act (SDWA), additional measures will be taken to address the possible formation of disinfection byproducts. The Stage 1 Disinfectants and Disinfection Byproducts Rule will require most large surface water plants, Including those on the Great Lakes, to begin monitoring Total Organic Carbon (TOC) of raw waters by January of 2002. TOC levels are an important indicator of water quality and the potential formation of disinfection byproducts. This Rule requires additional treatments to address disinfection byproducts If TOC standards are exceeded in the raw water intake. This preventative measure will help insure that the subsequently treated water is of a high quality.

The SDWA also requires Source Water Assessments (SWAs) to be completed by 2003 for all public water systems. SWAs are largely qualitative assessments of potential vulnerabilities in the system, identifying intake points, potential contaminant sources, drainage area, etc. SWAS are conducted by the States and Tribes, and implementation measures to reduce vulnerabilities will be carried out by the States, Tribes, and local governments.

Key Action:

Beginning in 2002, USEPA, in cooperation with local utilities, will track water quality at the intake points of selected drinking water treatment plants around the Lakes. Findings will be reported to the public through the biennial SOLEC State of the Lakes report.

PROMOTING CLEAN AND HEALTHY BEACHES

Most Great Lakes beaches provide a safe and enjoyable location for outdoor recreation and swimming. Past monitoring studies have shown that beach pollution is usually infrequent or confined to areas near pollution sources after a heavy rainfall or where a sewage treatment plant malfunctions. However, recent increases in beach advisories have suggested that there may not be enough information available now to fully define the cause and extent of beach pollution throughout the Basin.

The majority of beach advisories are due to indications of the presence of high levels of harmful microorganisms (e.g., E. coli) found in untreated or partially treated sewage. Sewage enters the water from combined sewer overflows, sanitary sewer overflows, and malfunctioning sewage treatment plants and septic' tanks. Untreated storm water runoff from cities and rural areas, which may contain wildlife feces and pet waste, can be an additional source of beach water pollution.

USEPA, in concert with States, eligible Tribes, and local agencies, will implement the newly passed Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000. The Act requires each State having coastal waters (which includes the Great Lakes) to review current water quality criteria and standards for coastal recreation waters of the State for certain pathogens, and adopt protective water quality standards. The Act authorizes studies and assessments regarding human health impacts of pathogens and the development of indicators for improving detection of pathogens in coastal waters. The Act also provides funding to States and eligible Tribes to develop and implement beach monitoring and notification programs, based on criteria outlined in USEPA's National Beach Guidance and Grant Performance Criteria for Recreational Waters.

Key Objectives:

- By 2010, 90 percent of monitored high priority Great Lakes beaches will meet bacteria standards more than 95 percent of the swimming season.

Key Actions:

- By 2005, States and local agencies win put into place water quality monitoring and public notification programs that comply with the USEPA National Beaches Guidance at 95 percent of all high priority Great Lakes beaches.
- By 2004 or according to approved TMDL schedules, States and local agencies will evaluate Great Lakes beaches which are closed more than 5 percent of the swimming season to determine pollutant sources.
- By April 2004, all Great Lakes States will adopt bacteria criteria at least as protective as USEPA's Ambient Water Quality Criteria for Bacteria—1986.
- By 2003, there will be pilot projects in the Great Lakes to support research being conducted on better indicators of the potential presence of pathogens, and rapid sampling technologies and techniques, for microbial and viral contamination to identify risk before exposure takes place.
- Federal, State, Tribal and local government agencies will work to reduce or eliminate closings, understand reasons for closings, and identify pollution sources at all monitored beaches closed more than 5 percent of the swimming season. USEPA win work with States to target CSOs, SSOs, and CAFOs that may be contributing to these beach closings in order to reduce or eliminate them as a source of pollution, and will target existing technical, administrative, and financial support to States and local agencies to assist in the identification and remediation of pollutant sources.
- USEPA will provide tools and available funding to State, local, and Tribal governments to improve infrastructure for monitoring Great Lakes beach water quality, communicating to the public and implementing actions to reduce closings. Such actions include:
  - Encouraging the States to ensure that a reasonable proportion of resources for infrastructure improvements be devoted to projects having a positive beneficial effect on the water quality of Great Lakes beaches.
  - Participating in conferences, workshops, and meetings to disseminate guidance and methods information to help beach managers and public health officials responsible for managing designated swimming waters develop or improve beach monitoring and notification programs.
  - Developing Great Lakes beach maps: beach location maps, including CSOs, SSOs, and TMDLs.
- Develop an Internet based site that allows for transfer of information on beach opening status to potential customers from beach managers. Link local Internet based sites to State and USEPA's BEACH Watch websites.
- Federal, State, Tribal, and local governments, private companies, and other Great Lakes partners will work collaboratively to develop rapid analytical methods for bacteria (E. coli and Entercoccus faecalis), for protozoa (Cryptosporidium parvium and Giardia Lambia), and for viruses (Norwalk and Rotavirus). As an interim measure, USEPA will support the development of local predictive models based on rain events.
- In cooperation with States and local partners, the USGS will continue to pursue research and development in recreational waters on methods to track pathogens and indicators to their sources and will continue to develop predictive models of beach-water quality through Cooperative Water-Resources Investigations Program and other programs.
- States' and local communities' Coastal Zone Management Programs, in cooperation with NOAA, will assist in providing access to public beaches.

PROMOTING A HEALTHY GREAT LAKES FISHERY

The fishery resources of the Great Lakes are held in trust for society and managed through State and Tribal fishery management programs. Fishery resources are managed for their intrinsic value and for their continuing valuable contributions to society. These include such benefits as: a healthy aquatic environment, aesthetic and recreational values, scientific knowledge and economic activity, as well as sufficient stocks of fish for commercial, subsistence, and recreational anglers.

Stressors affecting fishery resources rarely act singly, often having complex interactions, and frequently impact several levels of the aquatic ecosystem. As a consequence, remedial management must address problems on a comprehensive whole-system basis. A natural focus of the fishery agencies, therefore, is the maintenance and development of entire fish communities which can provide improved contributions to society. Such an ecosystem approach requires the protection and' rehabilitation of aquatic habitat and fishery management to ensure stable self-sustaining populations. This approach also requires the judicious stocking of hatchery-reared fish

to meet public demands for recreational fishing opportunities and to rehabilitate depleted stocks of desirable species.

The Great Lakes Fishery Commission (GLFC) is a binational organization whose commissioners are appointed by the United States and Canadian Federal Governments. It is responsible for the management of sea lampreys in the Great Lakes Basin, supporting fisheries research, and advising the U.S. and Canadian governments on means to improve the productivity of Great Lakes fisheries. The GLFC's Lake Committees, consisting of representatives of State, Provincial and Tribal Fishery agencies, have' developed fish community objectives for each lake.

Key Actions:

- Support GLFC Lake Committees' fishery management efforts so that each lake supports a healthy and productive fishery, including naturally reproducing populations of native fish.[7]

PREVENTING UNPLANNED INTRODUCTIONS AND CONTROLLING INVASIVE SPECIES

Invasive species adversely affect both the economy and ecology of the entire Great Lakes Basin, including aquatic, wetland, and terrestrial ecosystems. Over 160 invasive species have entered the Great Lakes-St. Lawrence system over the last 150 years. Almost one-third of such species have been introduced since the late 1950's, coinciding with the opening of the St. Lawrence Seaway system and the associated transport of invasive species in ballast water of commercial vessels. Once lathe Great Lakes, these invaders can spread to nearby inland lakes and distant ecosystems, including the vast watershed of the Mississippi River[8].

The Department of Agriculture has major programs to address invasive species on farmland, but these efforts are narrowly focused and distributed among different units of government on public and private non-agricultural lands. Similarly, authorities and responsibilities for addressing aquatic invasive species are shared among various agencies, with the exception of the Great Lakes Fishery Commission that was specifically created to control the invasive sea lamprey. SInce 1991, the Great Lakes Commission has convened the Great Lakes Panel on Aquatic Nuisance Species which has promoted the coordination of prevention and control efforts. The panel membership is drawn from U.S. and Canadian Federal agencies, the eight Great Lakes States and the province of Ontario, tribal authorities, regional agencies, user groups, local communities, tribal authorities, commercial interests, and the university/research community. A Great Lakes Action Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species has been recently adopted by the Great Lakes States and Canadian Provinces. The Action Plan includes the goals of preventing introductions, limiting the spread, and minimizing the impacts of aquatic nuisance species. The Action Plan also includes numerous principles, objectives, and strategic actions.

Improved coordination and cooperation of Federal, State, and Tribal efforts will be needed to prevent invasive species from entering and becoming established in the Great Lakes Basin, as well as to research and develop adaptive management strategies that lessen the ecological and economic impacts caused by invasive species already established in the Great Lakes Basin. The partners to this Strategy will work together through existing institutional arrangements, such as the Great Lakes Panel on Aquatic Nuisance Species, and create new initiatives as necessary to advance the prevention, containment, and control of invasive species. The ultimate goal is to eliminate further introductions of invasive species to the Great Lakes Basin.

Key Objectives:

- By 2010, substantially reduce the further introduction of invasive species, both aquatic and terrestrial, to the Great Lakes Basin Ecosystem.

Key Actions:

- Ensure that all vessels entering the Great Lakes comply with ballast water management standards developed by the U.S. Coast Guard (USCG). Currently, these standards require open-ocean ballast water exchange where feasible. The USCG is currently developing new, environmentally protective standards to guide

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[7]The GLFC Lake Committees' efforts are consistent with the Annex 1 of the GLWQA, which States that lake trout should be maintained as the top predator in Lake Superior.

[8] Since 1848, the Chicago River diverts some of the waters of Lake Michigan into the Mississippi River watershed as a means of alleviating water quality concerns in Lake Michigan and to provide a navigation link between the Great Lakes and Mississippi River.

the development and implementation of the next generation of ballast water management technologies.

- Implement ongoing research activities and adapt strategies to contain and control aquatic and terrestrial Species that have already invaded the Great Lakes Basin, in order to reduce their negative impacts on native biota and their habitats.
- By 2005, through the cooperative effort between NOAA and other agencies, determine the efficiency of open water ballast water exchange as the primary method to prevent introductions via ballast water,
- By 2005, through the cooperative effort between NOAA, USEPA, USCG, and the Great Lakes shipping industry, determine the potential threat of "no ballast on board" (NOBOB) vessels and prioritize actions to address this issue.
- By 2005, further investigate the relative risk from other sources and pathways or including new invasive species, including bait fish, recreational boating, cargo, ornamental plants, and aquaculture.
- Develop cooperative programs between Federal agencies and representatives of foreign governments to identify potential source regions and pathways and to anticipate and prevent invasive species introductions Into the Great Lakes Basin.
- Provide information and Great Lakes perspective to Congress for consideration during the Act (NISA), which is expected to occur in 2002, as well as to the International Maritime Organization policy forum, which is currently developing a global policy for ballast water management.
- By 2003; develop a framework to integrate and coordinate multi-agency responses, including Federal, State, Tribal, and local agencies, to address and potentially control new invasive species as soon as they are discovered.
- Continue to examine and implement chemical, physical, and biological control methods to address already established species, including the use of barriers, such as the dispersal barrier at the Chicago Sanitary and Ship Canal, to restrict the spread of aquatic invasive species.
- Continue to support a variety of programs to help recreation boaters ensure that their boats do not transport invasive species via motor props, hull fouling, or in bait tank water.
- Continue and expand research to determine the spread and impacts (biological and economic) of invasive species in the Great Lakes Ecosystem.
- By 2006, coordinate and enhance the monitoring of high-risk areas for the early detection of invasive species.

WORKING TOGETHER: EFFECTIVELY COORDINATING PROGRAMS AND RESOURCES TO PROTECT AND RESTORE THE GREAT LAKES

Goal: To work together as an environmental community to establish effective programs, coordinate authorities, and hold forums for information exchange and collective decisionmaking, so that the Great Lakes are protected and the objectives of the Agreement are achieved.

IMPLEMENTING THE GREAT LAKES WATER QUALITY AGREEMENT

Binatlonal responsibility for the protection of the Great Lakes is a necessity as four of the five Great Lakes are shared by the United States and Canada. Beginning in 1909 with the signing of the Boundary Waters Treaty between the United States and Canada, there have been over 90 years of international and interstate cooperation on Great Lakes issues. The GLWQA was signed in 1972, and was amended in 1978, 1983, and 1987. It was reviewed by the United States and Canada in 1999–2000 and will be reviewed periodically in the future.

The GLWQA establishes environmental goals and commitments for the Great Lakes to monitor and control pollution and water quality throughout the Basin. These goals help to establish joint priorities and lay the groundwork for joint strategies to clean up and protect the Great Lakes. The GLWQA has served as a prime example of international cooperation to address issues of mutual concern. The evolution of this institutional framework serves as a model for other areas of the country and for other countries to follow in the 21st century.

As outlined in Annex 2 of the GLWQA, the Great Lakes Program is characterized by three progressive scales of problem definition: "Basin-wide", "Lake-wide" and localized "AOCs." Environmental problems are addressed at different scales depending on their scope, in order to design effective, prevention and control strategies. Consequently, the Great Lakes Program involves a "nested" set of activities, managed and implemented by an alliance of Federal, State, Tribal, and non-government agencies. LaMPs and RAPs are the major organizing tools of the program.

THE INTERNATIONAL JOINT COMMISSION'S OVERSIGHT ROLE

The International Joint Commission (IJC) was established under The Boundary Waters Treaty of 1909. The IJC is an independent international organization charged with preventing and resolving disputes over the use of waters shared by the United States and Canada. Under the GLWQA, the IJC assesses progress and makes recommendations to the Parties to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem.

The IJC's Water Quality Board is the principal advisor to the IIC on all matters related to the GLWQA. In 1996, The Water Quality Board made recommendations to the Parties on broad desired outcomes for the Great Lakes. These outcomes appear in Appendix 2.

The USPC coordinates with the IJC and its boards, using existing mechanisms and protocols. It reports progress and provides responses to IJC recommendations to improve GLWQA implementation.

IMPLEMENTING LAKEWIDE MANAGEMENT PLANS

The Great Lakes Basin presents challenges owing to its vast area, multiple-jurisdictions, and the unique character and nature of each Lake and its problems. For these reasons, a separate LaMP has been or will be developed for each Lake. Each LaMP's primary goal is to support the overall goal called for in the GLWQA to restore the chemical, physical, and biological integrity of the Great Lakes, and to serve as a mechanism to more specifically address a variety of ecosystem stressors or beneficial use impairments as listed in Appendix 1, such as critical pollutants, habitat protection and loss, nutrient loadings, and the control of invasive species. Loadings of critical pollutants to the open lake waters will continue to be reduced through the development and implementation of the LaMPs.

The LaMPs will serve as the primary delivery mechanism for the coordination and planning of environmental/ecosystem protection activities for the Lakes. Each LaMP includes an identification of priority actions, and Implementation schedules and responsibilities. As of the date of this Strategy, LaMPs for Lakes Michigan, Superior, Erie and Ontario have been published. A Lake Huron Initiative (LHI) began in 1999, was published, and is moving forward. The United States and our Canadian partners have agreed to Issue LaMP updates every 2 years, which will report on progress and incorporate new information as it becomes available. The LaMP process will assist in coordinating U.S. activities with Canadian Federal and Provincial governments, and among Federal, State, and Tribal agencies within the United States on a lake-specific basis.

Key Actions:

- Continue to implement LaMPs. By April 2002, complete update of LaMPs and report on implementation progress. Issue updates on a 2-year cycle.

CLEANING UP AREAS OF CONCERN THROUGH REMEDIAL ACTION PLANS

The United States and Canada have identified 43[9] geographic problem areas around the lakes called AOCs. There are 31 AOCs in the United States, and five of these are shared with Canada. For each AOC, a Remedial Action Plan (RAP) has been developed. Each RAP identifies the nature, cause, and extent of the environmental problems (beneficial use impairments) in the AOC and develops appropriate remedial response actions. Remedial response actions are implemented through the use of Federal and State programs and authorities. Clean up work in these areas has gone on for several decades, and recently there has been heightened attention to accelerating cleanups and delisting of AOCs.

USEPA, its Federal partners and the States will continue to clean up AOCs and will move forward to delist areas where beneficial use impairments have been restored. A U.S. Delisting Principles and Guidelines will be published by the end of 2001.

Key Objectives:

- Delist at least three AOCs by 2005 and a cumulative total of 10 by 2010. AOCs that are initial candidates for meeting the first part of this goal are Waukegan Harbor, IL; Presque Isle Bay, PA; and Manistique, ML

Key Actions:

- Complete final U.S. Delisting Principles and Guidelines by the end o12001.

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[9] Collingwood Harbor, Ontario has been delisted.

• By 2002, evaluate the use of a new management paradigm for AOC5 that better demonstrates and tracks progress toward restoring beneficial uses.
• Bring all RAPs to implementation phase by 2005. Special Focus Area: Lake St. Clair

USEPA sponsored a Lake St. Clair conference in December 1999, which highlighted environmental concerns in this Important binational waterway, including sediment contamination, non-point source pollution, sewer overflows, fish advisories, and impacts from jnvasive species. Despite these problems, the lake is also recognized, through the SOLEC process, as an ecologically rich area. Efforts are now underway to address these issues, and to document historical conditions and existing high-quality habitat. Lake St. Clair has been identified as a special focus area and current and future activities are planed to protect the watershed.

Key Actions:

• Support the development of a locally driven, binational program to coordinate management of Lake St. Clair, including habitat assessment, monitoring coordination, and periodic "State of the Lake" reports and conferences.
• Support the development of a larger advisory forum from the binational community. Reporting on Environmental Indicators-Data and Trends

As part of the Great Lakes Ecosystem, humans have bad an undeniable impact on the health of all ecosystem components.. To gain an understanding of the status and trends of the health of the Great Lakes and its ecosystem components, a set of indicators have been developed. No one organization has the resources, expertise, or the mandate to examine all aspects of the State of the Lakes. However, dozens of organizations and thousands of individuals routinely collect and analyze data, and report on parts of the health of the ecosystem.

Because of the size of the Great Lakes and the number of collecting and reporting jurisdictions, a consensus by environmental management and natural resource agencies and other interested stakeholders regarding necessary and sufficient information to characterize the State of the Lakes Ecosystem is a way to facilitate more efficient monitoring and reporting programs. The relative strengths of the agencies will be utilize to improve the quality and timeliness of data collection, avoid duplication of effort, and make the information available to multiple users, including the general public.

The dialog developed as part of the biennial SOLEC has been an appropriate launching point for addressing and agreeing on indicator development, information gathering, and reporting. The SOLEC process, which is binational, has identified over 80 indicators to date that will provide information on all components of the Great Lakes Ecosystem. These indicators will provide information to the public, the LaMP committees, and a wide spectrum of other Federal, State and Tribal agencies to gauge the health of the lakes. Trends and status will be coordinated with the Government Performance and Reports Act requirement to insure fully coordinated reporting processes and procedures. In addition, a Lake Michigan Monitoring Council has been formed to assist in ensuring that monitoring resources and information is shared, coordinated, and support agreed upon indicators. This effort will serve as a model for other Lakes.

Key Objectives:

• By 2006, the SOLEC, LaMP, and RAP processes will provide clear information on Great Lakes water quality measures, trends, and actions (e.g., water quality trends, fish tissue trends, beach closures, RAP and LaMP Implementation, ecosystems restored); will be accessible to the public via the Internet; and will be updated on a regular basis.

Key Actions:

• Continue supporting SOLEC indicator process, through a network o Federal, State, Tribal and non-governmental groups. Include reports on indicators and ensure the process is fully coordinated at the Lake-wide and local levels.
• Support the establishment and operation of Lake-specific monitoring committees designed to coordinate monitoring, data gathering, and data quality activities by multiple agencies and organizations.

ESTABLISHING RESEARCH PRIORITIES FOR THE GREAT LAKES

The challenges facing the Great Lakes community are complex and interrelated. Addressing all of the multiple challenges discussed in this Strategy requires a strong, well-focused research program. Scientifically sound management decisions based on fundamental ecosystem understanding and reliable facts about human health and the environment are the keys to success. New research technologies

must be developed to identify and assess environmental stressors. New remedial technologies must be developed to help restore and sustain the natural resources of the Ecosystem. The Great Lakes community is fortunate to have numerous Federal, Tribal, State, Provincial, and university research organizations that are poised to fulfill these scientific needs.

The International Joint Commission's Council of Great Lakes Research Managers (CGLRM) has a responsibility to identify binational research priorities and emerging issues relative to the Great Lakes Water Quality Agreement. In addition, the Council produces an annual Great Lakes Research Inventory.

The information produced by the Council can be used to identify the scientific knowledge gaps that limit the ability of Great Lakes managers to meet specific goals of the GLWQA. The research priorities and Research Inventory can assist Federal, Tribal, State, Provincial, academic institutions, and funding organizations in developing research objectives for the Great Lakes.

Most agencies conduct or fund research that address their mission-specific priorities. Though communication and collaboration, information is developed that provides the science-based decisionmaking framework for the management goals and key objectives throughout this strategic plan. Examples of several agency research programs follow:

A broad research foundation is necessary for understanding the ecosystems that support the Great Lakes. NOAA has a very broad and multidisciplinary scientific mission in the Great Lakes. NOAA, through the Great Lakes Environmental Research Laboratory and through the Sea Grant Research and Extension Program conducts research and monitoring that provides the fundamental understanding necessary to model and predict the structure and function of aquatic environments and to identify and integrate information to improve the scientific basis for decisionmaking. GLERL houses a unique combination of scientific expertise in ecosystem modeling and food webs, biogeochemistry, invasive species, physical limnology, fish ecology, climate, contaminant cycling, and water resources. New tools, approaches, and models use the new knowledge and the growth of understanding obtained to advance assessment and prediction. Improved models are able to better predict ecosystem behavior, and hence offer better guidance to resource managers and decisionmakers. NOAA research partnerships with academia, with other Federal agencies, and with the private sector are critical components in an overall strategy to provide our Nation's leaders with the knowledge and application-oriented findings and recommendations they need to make informed decisions.

The U.S. Geological Survey (USGS) is a science and Information agency that plays an important role in providing sound information on the environmental and natural resources to management and regulatory agencies. In the Great Lakes region, the USGS Great Lakes Science Center in Ann Arbor, Mi (and its eight field stations and fisheries research vessels on each lake) and the USGS water resources offices in each of the eight Great Lakes States are the most well known units of the USGS. The Great Lakes Science Center conducts annual fish stock assessments, fishery research, coastal and wetlands ecology, terrestrial ecology with emphasis on Federal public lands, and non-indigenous species research. The water resources offices conduct tributary monitoring programs and a wide spectrum of surface and groundwater research. Recently, the USGS embarked upon a strategic change initiative and is promoting integrated scientific investigations that take advantage of its expertise in biology, geology, mapping, and water disciplines and to enhance its partnerships with other organizations in order to better address the resource issues nationwide and specifically in the Great Lakes region.

The USEPA Office of Research and Development, in partnership with Program and Regional Offices, has established Clean Water and Sound Science research strategies that address national needs to advance monitoring designs for assessing the ecological condition of aquatic resources, develop techniques to identify causes of impairments, establish nutrient, habitat and toxics criteria, and forecast future condition to support risk-based remediation and restoration options. Consistent with development and implementation of these strategies,. USEPA's research effort in the Great Lakes Basin parallels the national effort. For example, the USEPA Mid-Continent Ecology Division in Duluth, MN, which is responsible (or coordinating and undertaking ORD's assessment and effects-based research in the Great Lakes Basin, meets semi-annually with the Great Lakes National Program Office to facilitate integration of the basin-specific efforts within' the national strategies.

To implement a synergistic research strategy, interagency research coordination will he accomplished binationally on a continual basis, through professional conferences, agency workshops, and related venues that address specific key research areas. Through ongoing efforts undertaken on multiple program levels, addressing

high priority research needs, the scientific community in the Great Lakes will assist decisionmakers in solving pressing environmental problems in the Basin.

ENSURING U. S. COORDINATION AND COOPERATION

The U.S. Policy Committee was reestablished and reinvigorated in 1999 and has spearheaded the development and implementation of this Strategy. The USPC is comprised of representatives of State, Tribal, and Federal agencies. The USPC will set overall priorities and coordinate the development of individual actions and commitments by each Agency to achieve the goals, objectives, and actions in this Strategy.

Each year the USPC will review the joint progress against priorities set and ensure collective accountability. In order to ensure progress and overall accountability for these joint priorities, the USPC will promote international, interagency, and cross-program coordination for the Great Lakes and ensure that the necessary communication and decisionmaking is occurring on a timely basis. The USPC may recommend adjustments in Agencies' actions to facilitate the accomplishment of this plan, as well as in other important related plans and initiatives such as LaMPs and RAPS. The USPC will be the key forum for developing U.S. consensus positions on Great Lakes environmental policy issues that will be coordinated with our Canadian partners.

FOSTERING BINATIONAL COORDINATION AND COOPERATION

The Binational Executive Committee (BEC) is a high-level forum composed of senior-level representatives of the IJSPC and Canadian counterpart agencies who are accountable for delivering major programs and activities to fulfill the terms of the GLWQA. The BEC derives its mandate from the provisions of the GLWQA which relate broadly to notification, consultation, coordination, and joint activity. In particular, Article X specifies the commitments of the Parties to consultation and review:

"The Parties (United States and Canada), in cooperation with State and Provincial Governments, shall meet twice a year to coordinate their respective work plans with regard to the implementation of this Agreement and to evaluate progress made."

The BEC meets twice a year to:

- Set priorities and strategic direction for binational programming in the Basin;
- Coordinate binational programs and activities;
- Respond to new and emerging issues on the Great Lakes, task existing or create new work groups to undertake designated activities; and
- Evaluate progress and ensure accountability for achieving commitments under the GLWQA.

PUBLIC INVOLVEMENT

Public involvement is an important aspect of the successful management of the Great Lakes. The partners of this Strategy recognize our trust responsibilities to the public and commit to seeking meaningful public involvement in our decisionmaking process. Major venues for public involvement include LaMP and RAP forums, each comprised of a broad array of stakeholders, as well as the biennial listening sessions at the EJC's Water Quality Forum.

We also recognize the extensive technical expertise of environmental organizations, public groups, educational institutions, and industry. The partners to this Strategy will actively seek views and perspectives on major activities through existing forums, focused public comment periods, and listening sessions.

Key Actions:

Continue to foster public involvement in Great Lakes programs by supporting AOC and LaMP Public Advisory Councils and Forums, and other specially designed mechanisms to obtain meaningful involvement.

COMMUNICATING AND REPORTING PROGRESS

The USPC will work with our Canadian partners to provide periodic updates and progress reports to the public and other entities that have an interest or role in Great Lakes environmental protection. The primary vehicle for this will be periodic reports such as the overall Report on the Great Lakes Ecosystem, required by section 118 of the Clean Water Act, as well as State and other Agency reports. Other important vehicles for reporting are the binational SOLEC report, and periodic updates and reports from the LaMP and RAP processes. The SOLEC report emphasizes the health of the takes from a scientific perspective. LaMPs and RAPs will re-

port on progress toward achieving ecosystem restoration goals and restoring beneficial uses. A comprehensive progress report on the Great Lakes Ecosystem will be provided to the IJC biannually, as required by the GLWQA. The partners to this Strategy commit to placing reports and information on the Internet on a timely basis so information can reach a wide audience. In our implementation of the Strategy, we will endeavor to reduce reporting overlap and redundancy in order to improve public comprehension of key issues and trends.

EMERGING PROBLEMS AND CONTINUING CHALLENGES

The environmental protection and natural resource management problems of the Great Lakes Basin are a great challenge. As our knowledge of the Ecosystem progresses, we can expect newly identified problems to emerge. This Strategy is not a static work plan, but rather reflects an ongoing commitment to the long-term protection and restoration of the Great Lakes.

Future challenges for the Great Lakes will continue to be in the area of traditional environmental protection, but other issues such as global climate change, impacts of energy policies, and water uses and exports may become increasingly important.

CONCLUSION

This multi-Agency Strategy charts the course of environmental protection and ecosystem management in the Basin for the' next 5 years and beyond to meet the environmental challenges facing the Great Lakes. The focus of this Strategy is on ecosystem management and environmental protection. We have identified a full array of specific initiatives and programs to improve the Great Lakes Ecosystem. Through this Strategy, we continue our tradition of building cooperation and coordination among partners that have a shared interest and responsibility to preserve and protect the Great Lakes.

This Strategy seeks to include our citizens and stakeholders in these actions as full participants who may take the lead in many areas. The States, Tribal, and Federal partners recognize the challenge of this effort but believe that such an approach is essential to achieving success. This Strategy demonstrates that we have entered a new era, with a commitment to renewing our partnership. We will continue to pursue cooperative actions to clean up and protect the Great Lakes. We recognize that the world's largest freshwater system and the vulnerable living resources that rely on it, merit the highest level of our efforts and attention.

Adopted by consensus of the USPC on February 22, 2002.

THOMAS V. SKINNER, *Chair*
U.S. Policy Committee

Released on April 2, 2002 in Muskegon, Michigan.

APPENDIX I

BENEFICIAL USE IMPAIRMENTS

ELIMINATION OF IMPAIRMENTS OF BENEFICIAL USES TO THE GREAT LAKES

The Great Lakes shall be free of the following as a result of human activities in the Basin:

- Restrictions on its fish and wildlife consumption
- Tainting of fish and wildlife flavor
- Degradation of its fish and wildlife populations
- Fish tumor or other deformities
- Bird or animal deformities or reproduction problems
- Degradation of benthos
- Restrictions on dredging activities
- Eutrophication or undesirable algae
- Restrictions on drinking water consumption, or taste and odor problems Beach closings
- Degradation of aesthetics
- Added costs to agriculture or industry
- Degradation of phytoplankton and zooplankton populations
- Loss of fish and wildlife habitat

APPENDIX 2

DESIRED OUTCOMES FOR THE GREAT LAKES ECOSYSTEM

Fishability—There shall be no restrictions on the human consumption offish in the waters of the Great Lakes Basin Ecosystem as a result of anthropogenic (human) inputs of persistent toxics.

Swimmability—No public bathing beaches closed as a result of human activities, or conversely, all beaches are open and available for public swimming.

Drinkability—Treated drinking water is safe for human consumption;, human activities do not result in application of consumption restrictions.

Healthy Human Populations—Human populations in the Great Lakes are healthy and free from acute illness associated with locally high levels of contaminants or chronic illness associated with long-term exposure to low levels of contaminants.

Economic Viability—A regional economy that is viable, sustainable, and provides adequate sustenance and dignity for the human population of the Great Lakes.

Biological Community Integrity—Maintenance of the diversity of biological communities, species, and genetic variations within a species.

Virtual Elimination of Inputs of Persistent Toxic Substances—Virtual Elimination of inputs of persistent toxic substances to the Great Lakes system.

Absence of Excess Phosphorus—Absence of excess phosphorus entering the water as a result of human activity.

Physical Environmental Integrity—Land development and use compatible with maintaining aquatic habitat of a quantity and quality necessary and sufficient to sustain an endemic assemblage of fish and wildlife populations.

Water Quantity—There will be no diversion of Great Lakes waters that adversely affects any aspect of the Basin.

THE INTERNATIONAL JOINT COMMISSION'S INDICATORS TO EVALUATE PROGRESS UNDER THE GREAT LAKES WATER QUALITY AGREEMENT

Note: The desired outcomes have been developed by an IJC indicator task force and are provided here for reference. For more information see: <http://www.ijc.org/boards/ietf/ietf.html>

APPENDIX 3

BINATIONAL TOXIC STRATEGY GOALS AND CHALLENGES FOR TILE UNITED STATES

- Confirm by 1998, that there is no longer use, generation or release from sources thatenter the Great Lakes Basin, of five bioaccumulative pesticides (chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene), and of the industrial byproduct octachlorostyrene. If ongoing, long range sources of these substances from outside of the United States and Canada are confirmed, work within existing international framework to reduce or phaseout releases of the substances.
- Confirm by 1998, that there is no longer use of alkyl-lead in automotive gasoline; reduce or replace by 2005, alkyl-lead in aviation fuel.
- Seek by 2006, a 90 percent reduction nationally of high level PCBs (>500ppm) used in electrical equipment
- Seek by 2006, a 50 percent reduction nationally in the deliberate use and 50 percent reduction nationally in the release of mercury from sources resulting from human activity.
- Seek by 2006, a 75 percent reduction nationally in total releases of dioxins and furans from sources resulting from human activity. Seek by 2005, reductions nationally In releases of bexachlorobenzene, B(a)P, and dioxins, from sources resulting from human activity that enter the Great Lakes Basin.
- Promote prevention and reduced releases of Level 11 substances. Increase knowledge on sources and environmental levels of these chemicals.
- Assess atmospheric inputs of persistent toxic substances. The aim of this effort is to jointly evaluate and report on impact of long range transport of persistent toxic substances from world sources by 1998. If ongoing long-range sources are confirmed, work within existing international framework to reduce releases of such substances.
- Complete or be well advanced in remediation of priority sites with contaminated bottom sediments, in the Great Lakes Basin by 2006.

Binational Toxic Strategy of 1997

<httpi/www.epa.gov/glnpo/p2/bns.html>

APPENDIX 4

ROLE OF PARTNERS AND AGENCIES IN THE GREAT LAKES BASIN

A number of Federal, State and Tribal agencies and jurisdictions have important and essential roles to play in Great Lakes cleanup and protection, are partners to this Strategy, and have significant authorities and resources that will be coordinated effectively to assist in accomplishing this Strategy. Following is a brief description of their roles and responsibilities with respect to Great Lakes cleanup and protection.

Role of the Great Lakes States and Local Partners

Each of the eight Great Lakes States has environmental and natural resource agencies or divisions. These agencies have primary responsibility in implementing key pollution control programs. In addition, they have developed many unique programs to meet the needs of the Great Lakes and have been leaders, individually and as a group, in addressing major environmental issues. The States have primacy in managing fisheries and many other natural resource issues.

Role of Great Lakes Tribes and Tribal Organizations

The Great Lakes Tribal Governments (over 30 U.S. Tribes) have important roles to play in ecosystem protection for the Great Lakes and will implement activities as part of the Tribal Environmental Agreements. In addition, many Tribes have participated in the development of this Strategy, and will assist in its Implementation. The Chippewa/Ottawa Treaty Fishery Management Authority and the Great Lakes Indian Fish and Wildlife Commission have also been invited to participate in implementing the Strategy. Activities within their jurisdictions will be identified and implemented as part of the Strategy.

Role of Federal Agencies

The Agency for Toxic Substances and Disease Registry (ATSDR) has funded epidemiologic research in the Great Lakes Basin since 1992. Over the past 3 years, the ATSDR Great Lakes Human Health Effects Research Program (GLHHERP) has made significant progress in reporting and evaluating findings that address public health issues from exposure to contaminants in the Basin.

The National Oceanic and Atmospheric Administration (NOAA) has environmental stewardship, assessment, and prediction responsibilities in the Great Lakes. The Office of Oceanic and Atmospheric Research, Great Lakes Environmental Research Laboratory conducts physical, chemical, and biotic research and environmental modeling, providing scientific expertise and services to manage and protect ecosystems. The laboratory's investigations help to improve the understanding and prediction of coastal and estuarine processes, including the interdependencies with the atmosphere and sediments.

Through the National Ocean Service's Office of Response and Restoration (OR&R), NOAA acts for the Secretary of Commerce on behalf of the public as a natural resource trustee agency to protect and restore aquatic natural resources and associated human-use services such as safe navigation and transportation via maintained navigation channels, recreation, commercial fishing, and flood control provided by wetlands. OR&R actively promotes protection of aquatic species and habitats by working with Federal, State, and Tribal agencies, as well as with industry, to assess and clean up contaminated sediments in the Great Lakes and receiving waters. OR&R strives to resolve liability for natural resource injury by restoring: habitat, affected species, and associated services provided by those natural resources. OR&R provides information on shoreline classification, occurrence of biological resources, and human-use resources to assist in remedial and restoration planning at contaminated sediment sites and to support spill response activities. OR&R also conducts prevention and preparedness activities to prevent further degradation of Great Lakes sediments.

The Office of Ocean and Coastal Resource Management, in partnership with State Coastal Zone Management programs, works with local communities and State agencies to preserve, protect, develop, restore, and enhance coastal zone resources. OCRM provides research, education, and protection of coastal and estuarine areas through the National Estuarine Research Reserve and National Marine Sanctuary

programs and fosters economic redevelopment through Brownfields Showcase Grants.

The National Centers for Coastal Ocean Science (NCCOS) conducts research, monitoring, and assessments of the coastal environment. NCCOS predicts impacts of pollution and coastal development on sensitive habitats and resources. NCCOS maintains contaminantmonitoring sites in Green Bay, and Lakes Michigan, Huron, St. Clair, Erie and Ontario to determine temporal contaminant trends.

The Office of Coast Survey provides surveying, nautical charts, and other navigation services for safe shipping and boating. National Sea Grant Program, a partnership between universities and NOAA, encourages stewardship of Great Lakes coastal natural resources by providing funding to area universities for research of biotic, physical, and chemical systems, and for education, outreach and technology transfer. National Environmental Satellite Data and Information Service, Cooperative Institute for Meteorological Satellite Studies (CIMSS) develops and implements techniques and products to improve severe storm forecasting.

The National Weather Service provides the weather and flood warnings, forecasts, and meteorological and hydrologic data used by research, environmental management, transportation, and community interests in the Great Lakes.

The U.S. Army Corps of Engineers (USACE) has responsibility for a civil works program under which it develops, maintains, and conserves the Nation's water and related land resources. It administers permit programs related to navigation and changes to the waters of the United States. The USACE plays a critical role in operating and maintaining the navigable waterways of the Great Lakes.

The U.S. Coast Guard (USCG) regulates pollution from ships, as well as the ship borne introduction of exotic species. Under the Oil Pollution Act of 1990, the Coast Guard has the lead responsibility for responding to oil spills in the Great Lakes. The USCO also works with USEPA to establish and implement area and regional Joint. Contingency Plans for spills of oil and hazardous substances in the Great Lakes.

Three agencies of the U.S. Department of Agriculture (USDA) assist landowners with pollution prevention and control of non-point discharges-from agricultural operations: the Natural Resources Conservation Service (NRCS), the Cooperative State Research, Education, and Extension Service (CREES), and the Farm Services Agency (FSA). NRCS provides national leadership in the conservation and wise use of soil, water, plant, animal, and related resources; it works directly with agricultural producers on pollution prevention and control of non-point source discharges from agricultural operations. It also has an urban conservation program that provides technical assistance on non-point sources, such as: constructionsite runoff, fertilizer and pesticide inputs from lawns and other grassed areas, septic systems, flood control basins, and sediment storage ponds.

The U.S. Environmental Protection Agency (USEPA) is responsible for the Nation's regulatory programs for air, water, pesticides, and toxic chemicals. USEPA also sets national direction in environmental policy. Great Lakes National Program Office (GLNPO) will further the systematic and comprehensive approach to ecosystem management of the Great Lakes, as required by the Great Lakes Water Quality Agreement, by working with the Canadians and with other Federal and State agencies to ensure that compatible and consistent approaches to environmental protection occur across the Basin. GLNPO will continue to provide leadership in updating and implementing this Strategy and will report overall progress, trends in environmental conditions, as well as specific accomplishments, in a timely manner to Congress and the public. GLNPO will assist the Regions and States in the implementation of the Great Lakes-efforts and will seek to fulfill its specific mission as set forth in Section 1 18 of the Clean Water Act. USEPA Headquarters, particularly the Office of Water and the Office of International Activities will continue to set overall national policy regarding USEPA's program and implementation of environmental statutes. USEPA Regions 2, 3, and 5 have important roles for carrying out Great Lakes programs, particularly through implementation and targeting of base program activities, and will continue this work to ensure mandates are fulfilled and goals are met.

The U.S. Fish and Wildlife Service (USFWS) serves as trustee to protect the interests of endangered species, migratory birds, and interjurisdictional fishery resources, such as the lake trout and lake sturgeon, and supports the States and other Federal agencies with population and habitat inventories. USFWS also manages 140,000 acres of Federal land holdings in the form of Fish and Wildlife Refuges in this Region and performs resource assessment and research. They are also responsible for Natural Resource Damage Assessments (NRDAs) to recover damages for injuries caused to natural resources (e.g., endangered species, migratory birds, and trust fisheries) by the release of hazardous substances.

The US. Forest Service (USFS) and the National Park Service (NPS) both play important roles as stewards of vast, and often unique, Federal land holdings. State and private forestry programs, a cooperative effort of the USFS and State forestry agencies, assist public and private landowners in managing and protecting forest resources.

The U.S. Geological Survey (USGS) conducts various core research and assessment programs within the Great Lakes Region among its four major discipline areas of biology, geology, mapping, and hydrology. The major activities within the geologic discipline include detailed geologic mapping of glacial materials in Illinois, Indiana, Michigan, and Ohio; studies of earth-surface processes in areas prone to shoreline erosion, landslides, and earthquakes; research into the potential effects of changing climate on the earth and its resources; and aquatic-habitat mapping in coastal areas. The major activities within the water discipline include water-quality assessments of nonpoint sources of natural and human-derived contaminants in the watersheds of Lake Michigan, Lake Erie, Lake St. Clair, and the St. Clair and Detroit Rivers;, water-quality research on emerging contaminants such as pathogens, pharmaceuticals, pesticides, and mercury; a streamflow-gaging program for appraisal and assessment of water-resource quality and availability, for flood warning systems, and for drought management plans; and a groundwater levels network for water use, environmental assessment, and ground-water management. The major activities within the biology discipline include fisheries research and assessment in the Lakes, biodiversity studies in terrestrial, aquatic and coastal habitats, and research into and assessment of invasive species and related control practices. Major activities within the mapping discipline include production of a vast array of mapping products describing the land surface, such as elevation maps, hydrologic maps, maps of land use and land cover, studies of land-surface change in urban and agricultural areas, and new technologies based on satellites and remote sensing.

Role of Binational Agencies

The Great Lakes Fishery Commission (GLFC) was established by the Convention on Great Lakes Fisheries between Canada and the United States in i955. The Commission develops coordinated programs of research on the Great Lakes, and, on the basis of the findings, recommends measures which will permit the maximum sustained productivity of stocks of fish of common concern. It also formulates and implements a program to eradicate or minimize sea lamprey populations in the Great Lakes., Role of Canadian Partners

Four of the five Lakes (all but Lake Michigan) are shared with Canada. Coordination with Canada involves Federal agencies, as well as provincial agency counterparts in Quebec and Ontario. The binational International Joint Commission is charged with advising the national governments on issues of concern regarding joint stewardship of the Lakes. The U.S. Department of State assists all U.S. Federal agencies as they address Great Lakes issues of concern to both countries. USEPA has lead agency responsibility for coordinating activities relative to the Great Lakes Water Quality Agreement with Canada (as amended by Protocol signed November 18, 1987). The Great Lakes National Program Office informs the Canada-Ontario Agreement (COA) Review Committee (soon to be replaced by the COA Management Committee) about matters related to water quality and fishery resources.

STATEMENT OF GARY ISBELL, OHIO DEPARTMENT OF NATURAL RESOURCES

On behalf of the State of Ohio and particularly the Department of Natural Resources, I want to express appreciation for the Committee's willingness to seek input on this serious issue affecting Lake Erie. It is great that there is such recognition of the value of Lake Erie to Ohio by our congressional delegation, and especially Senator Voinovich. When Senator Voinovich was our Governor, I personally had the opportunity to share with him our common concern for the lake and our common appreciation for the fantastic yellow perch and walleye fishing. As we examine and discuss the current issue, let's not allow people to erroneously conclude that the lake is dead or that the fisheries are not outstanding. This truly is one of the top fisheries in the country. While the rampant pollution problems of the 1960's and the images of the burning Cuyahoga River are gone, there are new challenges to the integrity of the lake's ecosystem and we must collectively address them.

The problem of the anoxic zone in Lake Erie is not that it exists, but that its size, frequency, and duration are changing. The anoxic zone is a naturally occurring phenomenon, but can be a serious detriment to the ecosystem if it gets too large, thereby limiting the potential of the lake to produce the benefits we enjoy. The real problem about the anoxic zone is that just when we thought we had it figured out and

managed, it is behaving in ways that we do not fully understand. We are unsettled by the observation that the reduction in nutrient loading, brought about by pollution controls over the last 30 years, appear to be trumped by something mysterious. A leading hypothesis is that zebra mussels are at the heart of the mystery, perhaps recycling nutrients that contribute to the development of a larger anoxic zone than we would expect.

What should be done?

First, we must be aware that there may not be a reasonable cure or fix to the current problem. However, we think that the collaborative study sponsored by the USEPA is a step in the right direction. Levels of nutrients in the lake and their effects on microorganisms were monitored fairly comprehensively in the past through a similar USEPA sponsored study. However, recent monitoring has not been funded sufficiently to help us detect problems or devise solutions. As a result, comprehensive phosphorus monitoring was discontinued in 1994. While sampling was resumed in 1996, it has not been consistent from year to year and coverage of the lake has been mostly limited to offshore sites. A stronger and more robust monitoring effort is justified and fundamental to the development of sound management strategies for the lake. This is an effort that is appropriate for Federal funding and leadership. We must have solid long-term data about the basic features of the lake in order to detect problems and prescribe solutions.

Second, this mystery about the anoxic zone is yet another wake up call about the seriousness of invasions of aquatic nuisance species. Each new invader brings with it a random box of mostly negative effects. Some of the effects are not so subtle, such as the predator-prey interactions of the sea lamprey that devastated fisheries in the last century. Sea lamprey control in the Great Lakes is a success story, thanks to congressional support of the Great Lakes Fishery Commission. Although difficult, these types of effects are much easier to model and to control than the ultimate effects of nutrient recycling on populations of walleye or yellow perch off Cleveland. It has been 12 years since passage of the first comprehensive Federal law regarding aquatic nuisance species. Even so, each year there are still more alien species that find their way to the Great Lakes. This is biological pollution that has the potential to permanently devastate many of the lakes' beneficial uses. A legacy we should strive to leave is a solid Federal policy that shuts the door to future invasions of the Great Lakes.

The anoxic zone mystery is just part of a larger, complicated set of issues. It is encouraging to us at the State level to see Congress taking an interest and being willing to act. We urge you to do so quickly by funding more comprehensive monitoring within the lake. Lake Erie, given its hydrology can change very quickly. Quick action may avert some significant and lasting negative effects. Also, we urge you act with a response that is appropriately scaled to the size of the problem. This is a huge resource; therefore, investigations and solutions will not be cheap. Water quality programs, lamprey control measures, electric fish barriers, and ballast water management systems may be very expensive. However, the billions of dollars of resource values that are generated in the Great Lakes are worth it. Finally, we urge you to act comprehensively. The anoxic zone problem is not an isolated issue within the Great Lakes ecosystem. It is critical for development of long-range solutions to address the influx of invasive species into our waters, as well. Therefore, I would encourage Congress to support a re-authorization of NISA and work collaborately in strengthening the monitoring and survey efforts necessary. With proper funding, numerous State, Federal and private entities could be utilized to partner in the effort to conserve and protect this resource.

Thank you again for the opportunity to provide input to the Committee on Environment and Public Works. Please feel free to call upon the State agencies for additional information or review of strategies that may evolve from your initiatives.

RESPONSES OF GARY L. ISBELL TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Mr. Isbell, do Federal laws regarding aquatic nuisance species need to be revised? What changes would you recommend to Congress? What is the proper role of State and Federal Government entities in aquatic nuisance species control efforts?

Response. Yes. Currently there is a draft law (National Aquatic Invasive Species Act) that is being circulated to Members of Congress. We would urge the Committee to give the law serious consideration, because it has many new provisions and timelines for prevention and control of nuisance species. We are currently reviewing the draft and will make comments directly and through various other entities (such

as the Great Lakes Commission's Panel on Exotic Species). We view the Federal role of prevention of aquatic nuisance species as absolutely critical. Primary needs are in the area of ballast water management and regulation.

Question 2. Mr. Isbell, what aquatic nuisance species has had the most damaging effect on Lake Erie? Are you aware of new species that threaten Lake Erie and the other Great Lakes? What is the State doing to address current and future species?

Response. Historically, sea lampreys have had the most significant direct effect on fish populations. However, zebra mussels have probably had the most far-reaching effect, due to effects throughout the food chain. There are many species still in Europe that probably could invade, but I do not know which ones are potentially harmful. Within the Great Lakes, the ruffe has invaded, but has yet to spread throughout the range we would expect. When it comes to Lake Erie, for example, we would expect for it to become abundant and to have a significant effect on other species. Ohio is doing what it can to address prevention and control through its Aquatic Nuisance Species State Management Plan. This is a multi-agency plan that uses State and some Federal resources to implement control and prevention strategies. Much of the efforts are in the area of information/education to limit the spread of existing species through the actions of anglers and boaters. There is some direct support for the control of purple loosestrife in Ohio marshes.

Question 3. Mr. Isbell, what is the most important challenge to Lake Erie water quality? What is the State doing to address that challenge?

Response. From my perspective, I would say that toxic contamination is the most important challenge. We still have many Areas of Concern. The State is doing its part via Remedial Action Plans, implementation of water quality programs, etc. This is an area when other agencies should have the opportunity to provide comment, as well (OEPA, Health, etc.).

Question 4. Mr. Isbell, please describe any research efforts being funded by the Lake Erie Protection Fund of oxygen depletion in Lake Erie.

Response. N/A

Question 5. Mr. Isbell, what progress has Ohio made toward implementing the Ohio Lake Erie Protection and Restoration Plan?

Response. Jeff Busch, Director of the Lake Erie Office, would be able to answer this question. I do not know.

Question 6. Mr. Isbell, the Lake Erie Quality Index is expected to be updated next year. Do you know if next year's report will show that we have made progress over the last 5 year

Response. N.A.

STATEMENT OF PROFESSOR DAVID A. CULVER, PH.D., DEPARTMENT OF EVOLUTION, ECOLOGY, AND ORGANISMAL BIOLOGY AND THE GRADUATE PROGRAM IN ENVIRONMENTAL SCIENCE, THE OHIO STATE UNIVERSITY,

The Problem: Lake Erie water quality affects drinking water, swimming, and fish survival High availability of phosphorus decreases Lake Erie water quality. Low water quality increases the amounts of taste and odor causing compounds and even toxic compounds from algae in drinking water. Toxic algae tend to float to the surface in later summer and can be blown to shore, increasing the likelihood they will be taken in by potable water intakes and causing risks for swimmers, and for wildlife, livestock, and pet animals that may drink from the shore of the lake. Toxic algae have been shown to negatively affect the food chain upon which fish depend. Bacterial contamination from combined sewer overflows similarly affects these groups.

Causes: The thin central basin hypolimnion makes it susceptible to anoxia

The cool layer at the bottom of the lake (the hypolimnion) receives too little light for much photosynthesis, and is cutoff from atmospheric oxygen because it is denser than the warm layer (epilimnion) floating on top. Because of the shape of Lake Erie, its central basin hypolimnion is only 2 or 3 m deep, whereas its epilimnion is 18 m deep. As the lake decreases to water levels closer to the long-term average, the hypolimnion can become even thinner. Algae and animals produced in the epilimnion die and release feces that settle into the hypolimnion, where they decompose, consuming oxygen. The more nutrients available in the epilimnion, the greater the algal growth there. The more algae produced, the faster the rate of consumption of oxygen in the hypolimnion. It is a race between the rate of consumption of oxygen and the occurrence of the totalcirculation of the lake in September, which is caused by cooling of the surface waters.

Effects: Low oxygen in the central basin bottom waters decreases fish habitat

Most fish species cannot tolerate oxygen levels less than 3 ppm (e.g. walleye, yellow perch), and some require 4 ppm or more. Because the central basin is very flat, an increase in the area where concentration at the bottom is less than 3 ppm will greatly decrease the area useable by game fish and small fish upon which they depend for food. Lower concentrations yet will kill the benthic insects (e.g., mayflies) and plankton that these fish eat.

Effects: Low oxygen in the central basin bottom waters recycles phosphorus, producing more algae Phosphate ions in the sediments are bound by iron and clays fairly well under aerobic conditions. When sediments become anoxic, however, the ferric iron is reduced to ferrous iron and the phosphate is then much more soluble and diffuses out of the sediment. This phosphate can be mixed up into the surface waters when the lake circulates in September, causing additional algal growth.

Effects: Algae decreased in abundance from 1970 to 1997, but have increased since then central basin algae biomass declined from 3 to 0.6 g/m3 from 1970 to 1997, but 2001 abundances (2.0 g/m3) (please see Figure 1) are now as high as they were in the early 1980's, suggesting that water quality improvements are being reversed. This is all reflected in the planktonic animals in the lake (Please see Figure 2). Algae increases are made up in part by toxic strains of Blue-green Algae, which had become rare in the early 1990's. EPA phosphorus data also show this trend. There is no evidence that increases in inputs from the watershed have occurred, although accurate estimates of inputs are difficult to obtain.

Possible Causes: Zebra mussels have recycled phosphorus

Zebra mussels have recycled phosphorus and nitrogen in algae that otherwise would have settled to the sediments and stayed there. They consume algae all year round, providing continuous recycling of nutrients that can encourage algal growth. Their effects will be particularly felt in the western basin and near shore, but these waters also flow into the central basin where the anoxic hypolimnion occurs.

Possible Causes: Quagga mussels are replacing zebra mussels

Quagga mussels (another introduced species) are replacing zebra mussels in the whole lake. Our preliminary data suggest quagga mussels excrete more phosphate and ammonia than do zebra mussels for equivalent-sized individuals.

Possible Causes: Combined sewer overflows bypass nutrient removal at sewage treatment plants

Phosphorus and nitrogen inputs to the lake are increased by storm-induced overflows from combined storm water and sanitary sewers.

Solutions: zebra or quagga mussels cannot be removed

There is no way to remove zebra or quagga mussels from the lake.

Solutions: decrease human input of nutrients

If recycling by animals in the lake is increasing, our only solution is to decrease inputs of nutrients, particularly phosphorus, from point and non-point sources. As the human population increases in the Lake Erie watershed, it will require even greater efforts to decrease nutrient inputs.

Solutions: support better nutrient modeling of the lake

Scientific studies of the interactions among water circulation, nutrient inputs, and the plants and animals in the lake are hampered by incomplete information on the sources and amounts of nutrients coming in from rivers and direct discharge into the lake. I recommend increased efforts in monitoring inputs of nutrients, especially phosphorus and nitrogen into the lake.

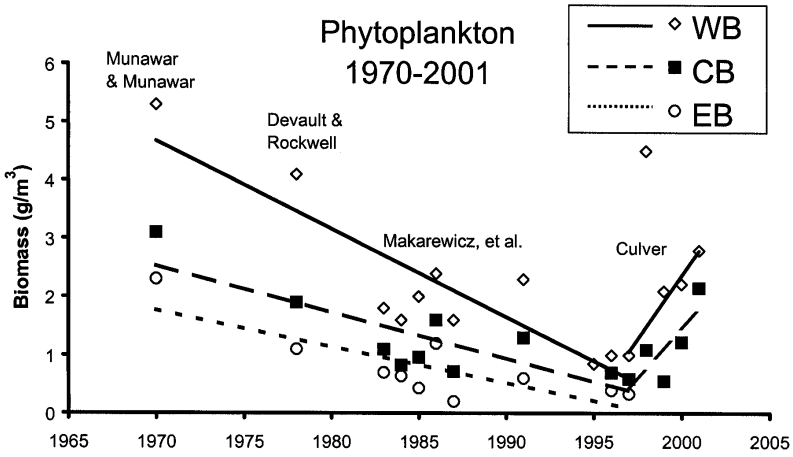

Figure 1. Seasonal (May-September) averages of phytoplankton algae wet weight (g/m3) in the western (WB), central (CB), and eastern basins (EB) of Lake Erie. The toxic Microcystis bloom in 1998 caused a very high algal weight (4.6 g/m3) in the western basin. This value was not included in the regression line. Names above the regression lines indicate the sources of data.

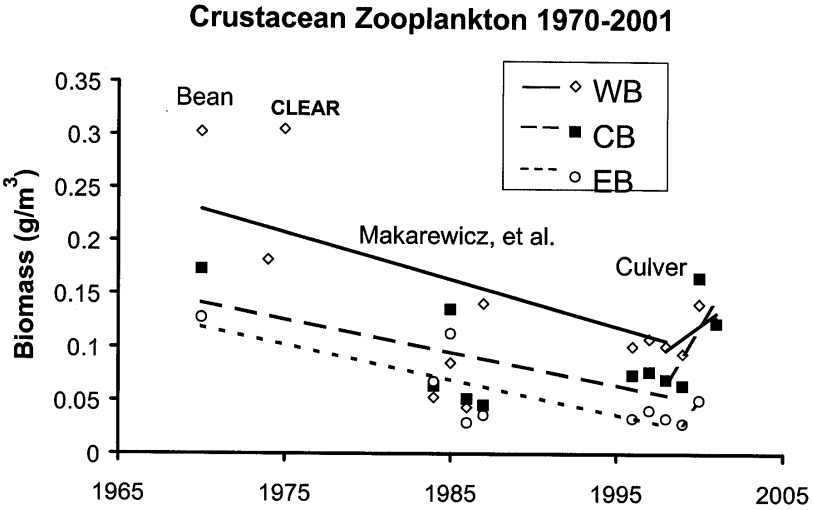

Figure 2. Seasonal (May-September) averages of crustacean zooplankton dry weight (g/m3) in the western (WB), central (CB), and eastern basins (EB) of Lake Erie. Contributions of rotifers and zebra and quagga mussel larvae are not included. Names above the regression lines indicate the sources of data.

RESPONSES OF DAVID A. CULVER TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Dr. Culver, in your testimony, you explain how zebra mussels recycle phosphorus and nitrogen that encourage algal growth. According to your testimony, their effects will be primarily felt in the western basin and near shore. Since anoxia is unlikely to occur in the western basin, what is their impact on the ecosystem in this region?

Response. The recycling of nutrients by zebra and quagga mussels in the western basin (and in the shallower regions of the central basin) will indeed return nitrogen and phosphorus to the dissolved phase that otherwise would have mostly stayed in the sediments. These nutrients stimulate the growth of algae, which is reflected in algal abundance in the western basin and nearshore areas of the central basin. In particular, as phosphate concentration increases, algal species composition changes from that dominated by the small algae easily edible by zooplankton that are fish food, to large, filamentous and colonial algae that are not. Some of these are the bluegreen algae that may release taste and odor compounds that are undesirable in drinking water or, worse, produce toxic compounds. Hence water quality and fish production in western basin and nearshore central basin areas may decline.

Furthermore, the warm western basin water does not stay there. Its volume is 25 km3, and outflow averages 13.7 km3/month. About 93 percent of the water eventually flowing over Niagara Falls or out the Welland Canal comes from the western basin. The central basin volume is 305 km3, so at least 23 percent of its surface volume is displaced by warm western basin water that is rich in nutrients and algae during the May-September period while the central basin is stratified thermally. This result is reflected in USEPA data for the last few years that show increases in the algal and nutrient concentrations in the western half of the central basin (but not in its eastern half). Therefore, external loading and zebra and quagga mussel recycling activities in the western basin can affect water quality (and oxygen consumption) in the central basin. We are attempting now to determine how much they do so.

Question 2. Dr. Culver, one of the messages I think I will take from this hearing is that more needs to be done to monitor inputs of nutrients into Lake Erie. In your opinion, what can be done to improve nutrient input monitoring?

Response. Nutrient inputs come from a variety of sources. At this time they are monitored as Lake Huron outputs (apparently ignoring the effects of Lake St. Clair), atmospheric inputs, monitored tributaries, unmonitored tributaries (estimated by comparing the area of their drainage basins with those of adjacent monitored tributaries), and point-sources (pipes from sewage treatment facilities, industrial discharges, etc.). Presumably the point source data are only from sites for which National Pollutant Discharge Elimination System (NPDES) permits have been issued with their associated requirements for self-monitoring.

David Dolan (Univ. Wisconsin—Green Bay) has calculated annual loadings for recent years at the request of the USEPA (to add to his previous estimates up to 1993) and found the nutrient inputs from Lake Huron, NPDES sites, and the atmosphere have been relatively stable over the last few years, with most of the variation in inputs being associated with the impact of varying rainfall on tributary inputs (monitored and, by estimation, unmonitored ones as well). The tributary monitoring is performed by various individuals, but most notably by the Water Quality Laboratory (WQL) at Heidelberg College, Tiffin, OH, in conjunction with the US Geological Survey (USGS). USGS monitors stream flow and coordinates those activities with those monitoring water quality in the Great Lakes basin. The WQL and USGS monitoring program is based on stations several miles above the confluences of four major rivers (Maumee, Sandusky, Cuyahoga, and Grand) with Lake Erie, so there is no opportunity to take into account the effects of sedimentation of materials and their resuspension during storm events. That is, temporal variation in nutrient flux at the monitoring stations can be very different from actual discharge at the river mouth due to resuspension (particularly after storms) and the input of point sources. Note also that the WQL does not monitor the Detroit River water quality. NPDES discharges are self-monitored by the entities holding the permits, and there is little independent confirmation of data received by onsite measurements by the USEPA or State agencies. Combined Sewer Overflows (CSOs) can discharge large amounts of nutrients and bacteria into the lake, but these events are poorly monitored, if at all, so we have little information on the amounts or timing of material discharged. Often events are only reported as having occurred, with no measurements of the amount of the discharge.

Historically, monitoring of Lake Erie nutrient inputs intensified in the 1970's, but decreased after the phosphorus loading targets were met in the early 1990's. The presumption was that less intense sampling was required because the lake water was clearer and the masses of bluegreen algae and Cladophora had abated. Those of us trying to estimate the contribution of zebra mussels, quagga mussels, and nutrient inputs into the lake, however, need to know the loading values for nutrients to model the system to estimate the mussels' impact. Annual loading estimates may be used as a "report card" of whether the lake's total loading is going up or down, but they do not serve the modeling community well at all.

Therefore, I propose that monitoring can be improved by: 1) adding regular (continuous, or at least weekly) nutrient monitoring of river mouths (including the Detroit River) for flow and nutrient concentration with increased frequency during periods of major discharge (e.g., after storm events); 2) regularly making independent measurements of nutrient loading from NPDES-permitted discharges, particularly sewage treatment facilities; and 3) monitoring the nutrient content and volume from large storm-water discharge pipes that may receive CS overflows.

STATEMENT OF DR. ROBERT T. HEATH, WATER RESOURCES RESEARCH INSTITUTE AND DEPT. BIOLOGICAL SCIENCES, KENT STATE UNIVERSITY

History of the problem of anoxia in Lake Erie: Anoxia in the bottom waters of Lake Erie has been observed since 1930 (Figure 1 from Bolsenga and Herdendorf 1993). Originally it was constrained to the Sandusky subbasin, the region of the lake north of Huron, between Sandusky and Lorain. As eutrophication of the lake increased in the 1960's and early 1970's the region of the lake that became anoxic in the summer spread to cover substantial portions of the sediments of the central basin of the lake.

Eutrophication of the lake was caused by excessive inputs of nutrients from human activities including sewage, industrial processes and agricultural fertilizers. High concentrations of nutrients in turn stimulated growth of noxious forms of phytoplankton (algae suspended in the water). These noxious phytoplankton (such as Microcystis) put compounds into the water that are distasteful and may be harmful to humans, thereby diminishing the quality of the water for fish and birds and for human consumption. These noxious phytoplankton also were inefficiently grazed by zooplankton, so the carbon fixed by photosynthesis of these phytoplankton was not moved efficiently through the base of the food web to higher organisms, such as fish and birds. Although these algae fixed large quantities of energy, it was wasted instead of supporting a healthy food chain. When phytoplankton died they sank to the lower reaches of the lake and were decomposed by bacteria that are natural components of the food web. The bacterial metabolic decomposition processes required oxygen, consuming all oxygen available, in turn leading to oxygen depletion in the lower waters of the lake. The oxygen in the lower waters is replaced only through circulation of the bottom waters with the oxygenated surface waters. Circulation is constrained because of the thermal stratification of the lake in the summer. Typically, complete re-circulation of the water column doesn't occur until the autumn and the decline of thermal stratification.

Mandated constraint of inputs of nutrients to the lake in the 1980's succeeded in reversing the eutrophication process. The essential nutrient in the least relative supply was identified as phosphorus (P). Limiting the input of P to Lake Erie was seen as the most efficient means of limiting growth of noxious phytoplankton. As the concentrations of P in forms readily available to algae and bacteria declined, the abundance of noxious phytoplankton declined and were replaced by species of phytoplankton that were efficiently grazed and did not diminish water quality with noxious exudates.

The reclamation of Lake Erie's water quality and its food web from the eutrophic conditions that existed 30 years ago is one of the major successes in large-scale ecosystem management. That success is now threatened by increases in phytoplankton production, return of some of the noxious phytoplankton species, and by an increase in the area of the lake covered by anoxia in the late summer. The cause of this is uncertain.

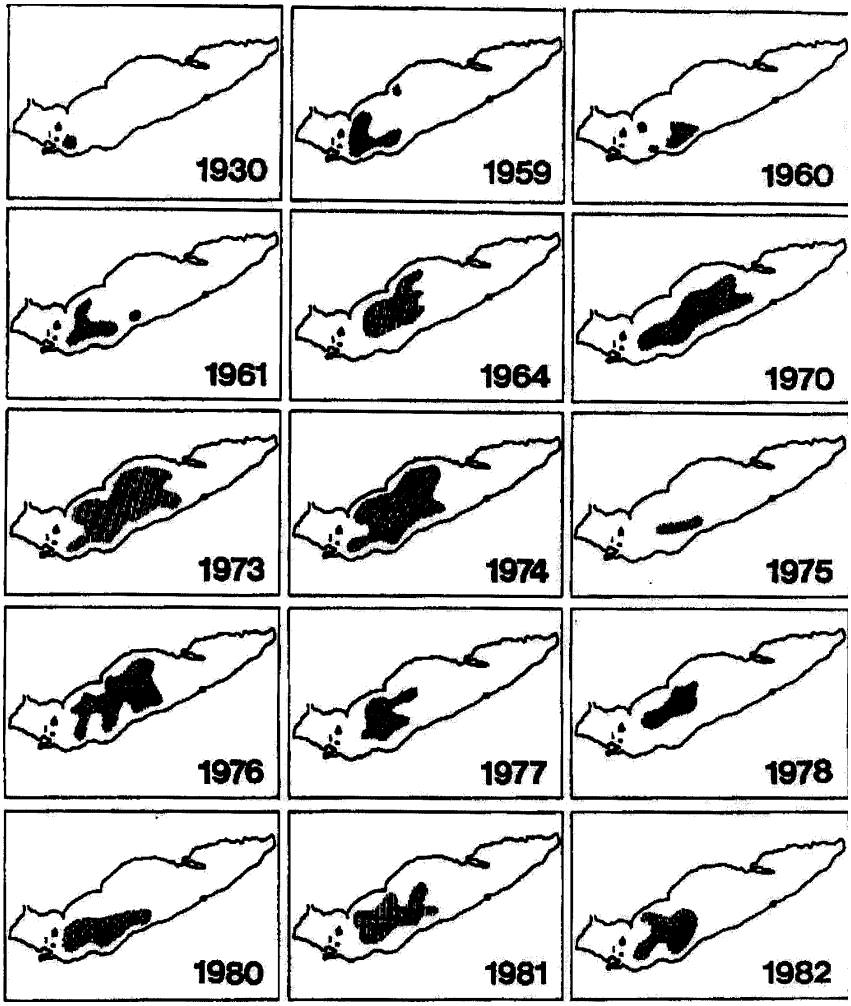

Figure 1. Anoxic regions of Lake Erie from 1930—1982. Shaded regions indicate anoxic regions detected in summer. From Bolsenga and Herdendorf 1993.

What is different this summer? For the past decade my research group has investigated the structure and function of the base of the food web, both under the influence of zebra mussels and in their absence. We have focused on the uptake and transport of carbon (C) and P because of the significance of these elements to the ecosystem function.

The base of the food web is comprised of phytoplankton, zooplankton (micro-crustaceans, rotifers and protists) and bacterioplankton. The bacterioplankton are a large number of species of non-pathogenic bacteria that are essential for performance of many ecosystem functions. The base of the food web is an interplay between growth of phytoplankton and bacterioplankton. The movement of energy and materials through the base of the food web can take two major pathways: 1) phytoplankton can be grazed directly by microcrustaceans or 2) dissolved photosynthate released by phytoplankton can support bacterial growth and a microbial food web. We have shown that the relative importance of these pathways is not constant in Lake Erie. The direct grazing pathway is most important in coastal regions of the lake and the microbial food web becomes relatively more important in

offshore and oligotrophic regions. As part of our research we have studied several sites that include the portion of the lake that most frequently became anoxic, the Sandusky subbasin (SSB).

Here I describe in brief our findings from the past 2 years in the SSB and compare them with our findings from two cruises in July 2002. The observations that I present here were taken from a station in the SSB near the international boundary:

LAT 41o 40' LON 82o 30'

Depth profiles of dissolved oxygen at this site are shown in Figure 2. Dissolved oxygen concentration was determined potentiometrically with a Hydrolab multi-parameter data sonde, calibrated within 24 hours of the observation. Oxygen depletion in the bottom waters at this station is not unique to this summer.

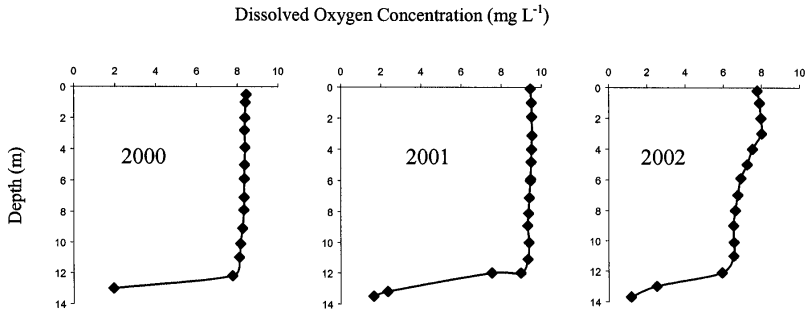

Figure 2. Depth profiles of oxygen concentrations during July 2000, 2001, 2002 at Sandusky Subbasin Station.

Following collection of physical variables onsite, water samples were collected and returned to the Biochemical Limnology Laboratory at Kent State University where we examined the status of the base of the food web. Our observations are summarized in Table 1. We also provide a comparison with the past 2 years and note observations that are statistically and scientifically significant in bold type.

Water transparency, estimated by the maximum depth at which a 20 cm white plate can be discerned—the Secchi depth—is significantly lower this summer than in the recent past indicating a significant decrease in the transparency of the water. We also observed a significant increase in chlorophyll content in samples over past years. This increase in chlorophyll supported photosynthesis. The "health" of the algae is indicated by the photosynthetic potential and the optimum photosynthetic rate, scaled for unit amount of chlorophyll. The observations indicate that the algae are growing actively; their photosynthetic capabilities do not appear to be limited by nutrient availability. Consistent with this is seen a significant increase in the amount of P in algal particles. When algae are in nutrient rich waters they store excess amounts of P in their tissues as insurance against nutrient limitation at a later time.

We also observe large amounts of P in bacterial particles. Bacteria growing actively increase their amount of P by increasing the amount of RNA, an essential biochemical necessary for protein synthesis and active growth. Active bacteria, in general, increase in size and rate of incorporation of dissolved carbon compounds. We observed that bacteria this year were significantly larger, and incorporated significantly more dissolved leucine (a dissolved biochemical compound we use to test their growth rate). Our observations are consistent with the view that bacterioplankton in Lake Erie are growing significantly faster than in years past—at least at the site and times we have investigated. Available-P, estimated both with a bioassay and by chemical means, does not appear to differ significantly this summer vs. previous summers. The amount of dissolved organic P (DOP) is significantly increased and the total P is significantly increased.

Our observations indicate that phytoplankton remain P-limited and susceptible to management plans devised around the assumption that they are P-limited. The phosphate turnover times of about 30 minutes indicate that the plankton community is P-limited but not severely so. If it were severely P-limited, many plankton would be capable of producing large amounts of alkaline phosphatase to obtain

available P from certain DOP compounds. Alkaline phosphatase is detected fluorometrically by the hydrolysis of methyl-umbelliferyl phosphate (MUP). The rate of MUP hydrolysis can be used to detect P-limitation, high MUP rates indicate severe P-limitation. The rates of MUP hydrolysis were modest, indicating that the community is not severely P-limited.

These findings (based on *very limited observations*) are consistent with the view that phytoplankton and bacterioplankton—the base of the food web—are more abundant and active this year in Lake Erie than in the recent past. We observe significant increases in the amount of P as dissolved organic P, forms of P available for phytoplankton growth only under certain conditions. The sources of additional DOP and the stimulation of plankton growth are unknown and a matter of concern and conjecture.

Table 1. Observations in Sandusky Subbasin during July 2000, 2001, and 2002.

Item	Meaning	July 2000	July 2001	July 2002
Secchi Depth (cm)	Transparency	455±13	607±0.02	**163±12**
Chlorophyll a (ug/L)	Est. algal abundance	1.0±0	---	**2.8**±0.3
P_{opt}	Opt. PS per unit chl.	2.93	---	2.12
Photosynthetic Potential	Est. of algal Physiological status	0.026	---	0.0096
Algal-PP (nM)	Algal mass est.	69±11	---	**697**±42
Bacterial-PP (nM)	Bacterial mass est.	54±4	---	**488**±50
Bacterial size (μm^3)	Bacterial Size	0.067±0.005	---	**0.18**±0.02
Bacterial # ($\times 10^5$ cells/ml)	Bacterial abundance	8.30±0.42	11.99±1.55	**2.77**±0.29
Bacterial Production ($\times 10^{-5}$ µgC/ml/hr)	Rate of bacterial production	12.1±3.5	14.1±1.0	**148** ± 3
Bacterial Respiration (µgC/ml/hr)		---	---	281±4
Bacterial Growth Efficiency (%)		---	---	34
BacAP (nM)	Bio. est. P–available	5.6±1.4	---	3.3 ± 0.5
SRP (nM)	Chem. est. P-available	100±50	undetectable	118 ± 7
DOP (nM)	Dis. Organic P	590 ± 40	200 ± 40	**6962** ± 150
TP (nM)	Total P	756±100	330±50	**8265**±242
P turnover time (min)	Est. of P-limitation	30.1±0.8	34.6±3.1	26.8±3.7
MUP (nM/hr)	Est. of P-limitation Via enzyme activity	43 ± 2	36 ± 2	24.2 ± 2.7

Bold: values taken in July 2002 that differ significantly from measurements made at similar times in 2000 and 2001 in same place of Lake Erie: Sandusky subbasin (SSB).

Implications for increased regions of anoxia: Given these observations, I believe a likely explanation for increased regions of anoxia in Lake Erie is increased production at the base of the food web. If these increased amounts of phytoplankton are incompletely grazed, they could sink to the lower regions of the lake on death and be decomposed by natural non-pathogenic bacteria that consume oxygen to depletion. I should like to emphasize that this explanation is not the only possible explanation; it is the one I regard as the most likely explanation. Natural geochemical and biological processes can also consume oxygen. Oxygen consumption by these natural processes is normally replenished by entrainment of oxygenated waters during storms. During unusually long periods of stagnation, oxygen can be depleted from bottom waters without extraordinary production occurring in the surface waters.

Possible Causes of increased phytoplankton and bacterioplankton growth: Because the phytoplankton appear to be P-limited (although weakly), I believe we need to examine possible sources of P and the processes by which it can be supplied at a rate to support increased phytoplankton growth.

External loading of P comes from the watershed but external to the lake. Such external sources can come from identifiable points (point-source loading: sewage treatment plants, combined sewer overflows, industrial effluents, etc.). Regulation of point source loading is strict and generally works well to control unwanted excessive inputs of P to the lake. Alternatively, non-point sources of P-loading from sources such as agricultural and residential runoff of fertilizers is not well regulated nor easily monitored because of its diffuse nature.

Internal loading of P is a term applied to processes that recycle P already in the lake from unavailable forms to available forms of P (e.g. inorganic orthophosphate). P is unavailable for growth of phytoplankton and bacteria when it is sorbed to sediments, when it is in dissolved organic P compounds (DOP), or when it is incorporated into living or dead organic particles. P sorbed to sediment surfaces can be released when the oxygen concentrations decline below 0.4 ppm. This means that when oxygen is depleted from waters immediately above the sediment surface, P can be released in a useful form by desorption, potentially further stimulating the growth of P-limited phytoplankton. P can also be released in useful forms through the action of certain enzymes capable of hydrolyzing specific DOP compounds (Francko and Heath 1979) or through photolysis of DOP compounds by UV light capable of penetrating several meters into clear lake water (Cotner and Heath 1990). High temperatures of the lake water can increase the activity of hydrolytic enzymes acting on enzyme-sensitive DOP; clear water and increased intensity of UV light can increase the rate of photolysis of UV-sensitive DOP.

Organisms grazing on particulate organic matter (e.g. living or dead tissue material) release P in available and unavailable dissolved forms. Increased grazing activities by zebra mussels and their congener, quagga mussels, may be a source of increased P-availability. My research over the past several years has shown that zebra mussels release sufficient available P to relieve phytoplankton in surrounding waters from P-limitation (Heath et al. 1995). Their effect on the whole lake community remains unclear (Heath et al. 2000), although they may exacerbate blooms of the nuisance cyanobacterium, Microcystis (Culver et al. 1999).

Conclusions and Specific Recommendations: It is not clear why the zone of anoxia has apparently begun to expand after at least a decade of being confined to small regions of the central basin of Lake Erie. With apparent increases in phytoplankton abundance, it is tempting to reminisce about the causes of large regions of anoxia observed during the 1960's and early 1970's. Anoxia of those days resulted from eutrophication due to excessive external loading of available P from point sources. Because of the great restrictions on point-source P-loading, it is unlikely that the current problems arise in the same way. The role of other sources needs to be investigated. It is unclear whether external non-point source loading from urban and agricultural sites or internal loading due to zebra-and quagga mussels or a combination of external and internal sources are capable of causing the problems currently observed.

I don't believe we need new research of the issues involved as much as we need new ways of placing current research into a more useful context.

(1) Research on ecosystem level effects of P-loading and the possible effects of dreissenid mussels need to be placed into comprehensive models useful for ecosystem management. The "Great Lakes Modeling Summit: Focus on Lake Erie" (IJC 2000) is an excellent point of departure for this purpose.

(2) Scientific research on the Great Lakes needs to move beyond its current ad hoc status by incorporating continuous comprehensive monitoring activities at levels far expanded beyond current efforts.

(3) The Great Lakes need to be valued as national (indeed, an international) treasures rather than being viewed as regional resources alone. Issues besetting the Great Lakes need to be addressed in innovative bi-national ecosystem research, monitoring and management programs.

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STATEMENT OF ELAINE MARSH, LAKE ERIE REGION REPRESENTATIVE, GREAT LAKES UNITED

Dear committee members: I am here as the Lake Erie regional representative on the board of Great Lakes United, an international not-for-profit coalition dedicated to protecting and restoring the Great Lakes-St. Lawrence River ecosystem. Great Lakes United's 150 member groups represent tens of thousands of people from the eight Great Lakes States and the Provinces of Ontario and Quebec.

The Great Lakes are the largest surface fresh water supply on earth, representing almost 20 percent of the world's fresh surface water. They are irreplaceable and nonrenewable—a gift of the last glacier, renewed at less than 1 percent annually.

There is no one answer to the question of why anoxia is occurring in the central basin of Lake Erie. We know that it is a historical problem since the 1930's, that it peaked in the late 1960's and early 1970's, and that it was largely alleviated at that time by pollutant and discharge regulation measures taken in the 1970's. Specifically, these included phosphorous controls including bans on phosphates in detergents and construction and upgrade of sewage treatment plants around the Great Lakes.

The research performed at that time alone gives us one important clue as to what is happening in Lake Erie. As the shallowest, Lake Erie is the most vulnerable of the Great Lakes to stress. Lake Erie is currently suffering from lower than normal levels and warmer than usual temperatures. At the same time, the sewage treatment infrastructure around the Lake is aging, and bacteria counts along many community shorelines are on the rise. This is indicated by the rising number of beach closings around the Lake after storm events, which cause combined sewer systems to overflow directly into tributary streams or into the Lake itself.

The nutrients in raw sewage fertilize vegetation in the Lake, especially algae, which grows, blooms, dies and decays. Decaying algae consumes oxygen.

The problem may be intensified by lower water levels, warmer water and clearer water. Clearer water allows sunlight to penetrate further, which again contributes to algae growth. Lake Erie waters are clearer since the invasion/colonization of the Lake by zebra and quagga mussels, which consume and filter floating debris. Mas-

sive die-offs and decay of exotic species unsuited to ecosystem conditions in the Lake may also be consuming oxygen.

Low water levels, exotic species and aging sewage treatment plants are all likely to be contributing to the anoxic conditions in Lake Erie.

These are large problems requiring large solutions. Great Lakes groups are calling for a new era of investment in sewage treatment. We believe the "dead zone" in Lake Erie and the increased number of beach closings around the Lake are strong indicators that untreated waste inputs are on their way to becoming a health crisis for Lake Erie communities. Great Lakes citizens are advocating an immediate end to combined and sanitary sewer overflows into Great Lakes waters, and mandatory notification of daily bacteria counts at public beaches to increase awareness as well as safety for the region's population.

We must protect Lake Erie and all the Great Lakes from new influxes of exotic species such as the zebra and quagga mussels which are thought to be linked not only to the anoxia in Lake Erie but also to the botulism outbreak that has devastated fish, amphibian and bird populations in the eastern basin. Great Lakes citizens are calling for invasive species legislation in Canada and the U.S. by 2004 that include ballast water standards that eliminate the risk of exotic specie introductions, or that foreign ships be restricted from discharging the contents of their ballast tanks at any time.

Finally, in terms of protecting Great Lakes water levels from the potential future effects of climate change, we need to greatly reduce CO^2 emissions from two major sources: coal-fired power plants and automobile emissions. Great Lakes citizen groups are advocating for mandatory caps on CO^2 emissions from the power and transportation sectors that guarantee reductions of CO^2 emissions by 60 percent by 2020.

In closing, we ask the Committee to support research on Lake Erie under the binational Lakewide Management Plan, headed by the EPA's Great Lakes National Program Office and Environment Canada's Great Lakes Program. The LaMP mechanism, set up under the Great Lakes Water Quality Agreement, includes the government partners as well as the public participation that are critical to successfully dealing with the complex set of events that are currently affecting Lake Erie.

We also ask the Committee to support restored funding to the US Fish and Wildlife Service Lower Lakes program to enhance monitoring and oversight of Lake Erie and Lake Ontario.

RESPONSES OF ELAINE MARSH TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Ms. Marsh, in your testimony you state that phosphorus controls have alleviated Lake Erie's problems over the last several decades. Given today's concerns, do you think we ought to do more to control phosphorus inputs into Lake Erie?

Response. Emphatically yes, Great Lakes United believes more needs to be done to control phosphorus. We need to determine and control the current loadings of phosphorus from all sources.

Current de-emphasis on tributary deposition

I have heard and read the statement that while the phosphorus levels in the Lake Erie are rising, levels in the tributaries are declining. This is certainly not true of the Cuyahoga River, the river with which I am most familiar. The phosphorus levels in the lower Cuyahoga exceed the Ohio EPA target levels during nearly all flow regimes. For many years, Hiram College has monitored a stretch of the lower river for a number of parameters, including phosphorus. Therefore, the phosphorus information that we have on the lower river is empirical, and we can have confidence in the data.

However, since phosphorus is not a regulated pollutant in the NPDES system, ambient phosphorus levels, both particulate and dissolved, may not be available in many tributaries. And while Storm Water Phase II may have some monitoring effect on the overall particulate forms of phosphorus, the program will not affect dissolved forms. And it is the dissolved forms which are of greatest concerns to the anoxia problem in Lake Erie.

Monitoring tributaries

Since phosphorus is not a regulated pollutant, consistent monitoring of total phosphorus and phosphates is not required. This can result in an inconsistent or sporadic monitoring program which may not capture an accurate picture of loading. Often, this sporadic information goes into modeling equations which drive conclusions and recommend technology controls.

The Lake Erie basin is a very dynamic system. We believe that too much of the information that we have about tributary loadings comes from incomplete, sporadic sampling. That information gets built into models. And while modeling is a very effective tool without which we would be very restricted, it only works in a system which is fairly predictable.

We believe that the Lake Erie monitoring and modeling system needs to be evaluated and revised. The current research effort should result in recommendations for a broader model and for an on-going monitoring program.

Also, current research efforts should identify all institutions that are currently monitoring phosphorus and establish a data collection system.

Partnering opportunities should be identified for major tributaries which have no current monitoring program.

Nutrient limits

We believe that EPA should move forward to regulate nutrient loadings. EPA has been studying this issue for the past several years. The agency should move forward to publish enact rules and guidance on nutrients. Phosphorus limits, regulated through the NPDES system, will greatly reduce phosphorus loading, regardless of their sources, as local and State governments will be required to examine strategies and policies to achieve compliance. To date, chemical numeric standards are the only enforcement strategy which has effectively and uniformly reduced pollution loading. Phosphorus limits in the NPDES system will be an effective way of reducing anoxia in the Lake.

CSOs and SSOs

These antiquated systems must be corrected. Billions of gallons of untreated water flow into Lake Erie each year. The amount of phosphorus this water contributes to Lake Erie is astonishing. With the nine minimum control strategy, we are beginning to quantify the contributions from CSOs.

In addition to phosphorus loading, CSOs take a weighty toll on recreation, human health, quality of life and economic development. Here in the Cuyahoga watershed, we enjoy the beauty of the Cuyahoga Valley National Park and of the Ohio and Erie Canal National Heritage Corridor. However, due to poor water quality in wet weather related to CSOs, water-based recreation, even wading, poses significant threat to human health. And along certain stretches of the Ohio and Erie Canal Towpath Trail, one of the nation's most visited trails, the smell of sewage is overwhelming.

Over the past several years, municipalities and sewer districts impacted by CSOs and SSOs have been arguing that wet weather standards should be lowered. They argue that the bacteria standards for primary contact cannot be attained in wet weather in urban stream. If this argument results in allowing CSOs and SSOs to continue discharging untreated waste into our streams, it will be a disaster.

Please help hold the standard. This is not the time to argue attainability.

Let's correct the sewers and then, perhaps, attainability might be a reasonable topic. There is no argument that can justify dumping untreated waste into our streams, our fishing holes, our canoeing rivers, our stone-skipping runs, or our drinking water source. We must rise to the occasion. We must for do it for health of our streams, the health of our children, the health of our local economies and the health of our future. And, we must do it in order to face our legacy with dignity. What will we tell the next generation if we don't solve this problem? How can we hold ourselves as the world's superpower and refuse to treat our own waste just because we don't want to spend the money?

Correcting CSOs will have a substantial effect on phosphorus loadings in Lake Erie and an enormous effect on recreation and quality of life in the basin.

We hope that the Senate will probe into the issues of funding and policy related to SSOs and CSOs. We hope that Senator Voinovich will continue to be a leader on this issue.

Non-point source contributions

Stream protection, wetland retention, control of impervious surfaces and urban forestry are topics that must be addressed in order to minimize run-off that contributes significantly to phosphorous loading. Ohio EPA research indicates that hydromodification and urban run-off are the largest—— growing causes of pollution in our streams. In order to reduce the phosphorus contributions from non-point sources, the Senate should enact laws that restore protection to isolated wetlands, protect and encourage the natural stream channel, encourage the protection and restoration of the flood plain, and encourage the preservation and restoration of the urban tree canopy.

What we have come to understand is that if we are to effectively manage our environment, we must expand our definition of infrastructure to include measures that

provide a sustainable environment. The environmental service of green infrastructure is as important as traditional infrastructure.

Engineers of our future infrastructure will include wetland ecologists, urban foresters and geo-fluvial hydro-morphologists. Lake Erie would be an excellent place to locate a large-scale demonstration project on green infrastructure as a strategy to reduce phosphorus loading. Certainly, the Cuyahoga River would be a likely spot for such a project.

Question 2. Ms. Marsh, what do you think should be done help prevent the introduction of additional aquatic nuisance species into the Great Lakes? What should we do to address species that have already been introduced into the Great Lakes? What is the appropriate role of the Federal Government and State government in aquatic nuisance species control?

Response. Aquatic nuisance species are arguably the No. 1 problem facing the lakes. Both existing but as-yet unidentified introductions and new introductions have the potential to catastrophically decimate the Great Lakes food web and general lakes ecology as we know it today. Current efforts to control new introductions are of extremely limited effectiveness. Attached to this submission are articles from past Great Lakes United newsletters that summarize current scientific research that addresses the severe potential consequences of the deficiencies of current aquatic nuisance species control programs.

Of top priority is the prevention of new invasive species into the Great Lakes basin. The United States should make protection from the introduction of all invasive species a national priority. Strong and fully funded national policy, such as the reauthorization of the National Invasive Species Act (being reauthorized as the National Aquatic Invasive Species Act) is critical for the long term prevention of introductions for all of the Nation. It must be noted that while the draft NAISA appears strong, it could take decades to realize the benefits from this legislation. The Great Lakes need better, more immediate protection.

Furthermore, strong national policies to prevent invasive species are moot if the Federal Government also pursues navigation expansion projects that would further facilitate, and increase the number of, future invasions into the Great Lakes. The current Great Lakes Navigation System review, which is in its draft reconnaissance phase, proposes to investigate the feasibility of expanding the Great Lakes navigation system to allow larger oceangoing ships into the basin. This approach to enhancing the movement of goods in the basin is problematic for many reasons. Perhaps the most important is the certainty of an increased pace of invasions from the ballast water of oceangoing ships.

The Federal Government should direct the Army Corps of Engineers to examine alternative means of moving goods through the Great Lakes basin that prevent new invasions and reduce the movement of invasive species within the basin. Great Lakes United articulated some alternative approaches to the Corps in an April 2002 letter. A properly designed study would look at:

- How to modify trade on the Great Lakes to reduce the overall impact of shipping trade on the Great Lakes-St. Lawrence River ecosystem
- The feasibility of restricting foreign ships that trade in the basin to a central transfer station in the lower reaches of the St. Lawrence River
- Assessing the environmental benefit of this trade modification on the lakes, the subsequent economic benefit associated with this environmental protection and the cost and benefit of establishing a fixed ballast water treatment facility to service both domestic and foreign ships trading in the Great Lakes-St. Lawrence River basin and the Laurentian channel.

These alternative approaches to the study of Great Lakes navigation could lead to basin transportation modifications that support both overall economic development and the vitality of basin sub-economies that depend substantially or entirely on the health of the ecosystem.

STATEMENT OF GERALD MATISOFF, PROFESSOR AND CHAIR, DEPARTMENT OF GEOLOGICAL SCIENCES, CASE WESTERN RESERVE UNIVERSITY

I am Gerald Matisoff, Professor and Chair of the Department of Geological Sciences at Case Western Reserve University. I have been asked to provide technical expertise to the Committee because of my role as Project Director of the EPA-funded grant "Lake Erie Trophic Status" which began this summer. I have also served as Editor of the Journal of Great Lakes Research for the past 5 years and have been active in Great Lakes research since the 1970's. Attached to this document is a CV which lists my publications pertinent to Lake Erie.

Provided here are brief comments about why anoxia is occurring in the central basin of Lake Erie, about the effects of anoxia on the Lake Erie ecosystem, and about solutions to prevent anoxia from occurring in the future. My comments are necessarily brief, in part because we don't have complete answers to all of your questions so more detailed explanations would border on speculation, and in part because of the limited time in which to prepare my report. I would be happy to provide you with additional information or answer additional questions at a later date.

Causes of Anoxia

Low oxygen during the summer in the bottom waters of lakes is a natural phenomenon. What happens is that heating of the surface of a lake during the spring warms the surface water. Since warm water is less dense than cold water, it floats on top, effectively isolating the cold bottom water from the atmosphere. As a result, although the surface water can replenish oxygen by exchange with the atmosphere the bottom water cannot. Bacterial respiration of organic matter in the water column and on the lake bottom consumes oxygen, so oxygen concentrations in the bottom water gradually decrease throughout the summer. Water with low oxygen concentrations are termed "hypoxic"; if oxygen concentrations go to zero, then the water is termed "anoxic." In the autumn, the surface waters cool and when the densities of the surface water and bottom water are the same the water column mixes vertically destroying the 2-layer stratification and oxygen is returned to the deeper water and nutrients in the bottom water are mixed into the surface water. This process is termed "fall overturn" and occurs in Lake Erie's central basin during August to September.

Human activity can and has exacerbated the development of anoxic bottom waters. The addition of algal nutrients such as phosphorus (and nitrogen in coastal ocean systems) from fertilizer derived from agricultural runoff and from sewage discharges has led to an increase in algal growth and a consequent increase in the amount of organic matter undergoing respiration and decay during the summer. This process is termed "eutrophication." The Great Lakes research community played a major leadership role in the 1960's and 1970's in demonstrating eutrophication control by phosphorus load reduction. The basic approach was to synthesize a great deal of eutrophication process-oriented research into complex mathematical models of the relationship between nutrient loads and eutrophication symptoms, then those models were used to set target P loads for each lake or major embayment, then the IJC recommended programs that would achieve those loads, then the Parties implemented those programs; and when the target loads were achieved the models were post-audited and in general found to be "right on" in their predictions. For Lake Erie that target load is 11,000 metric tons of phosphorus per year. Twenty years later this process has been heralded as one of humankind's greatest environmental success stories and since then it has been copied and implemented in numerous other locations throughout the world.

Data from the IJC and from EPA indicates that the phosphorus loading goal of 11,000 metric tons per year has, more or less, been achieved on a regular basis over the last decade or two. So the question is why, if phosphorus loading goals have been met, are anoxic bottom waters recurring in the central basin of Lake Erie? My multi-investigator research project, "Lake Erie Trophic Status" is an initial survey to begin to answer this question.

There are at least three potential explanations which are illustrated in Figures 1 through 3. The first hypothesis is that the problem is climate related (Figure 1). Variations in climate which lead to a longer time period in which the lake is stratified or leads to a thinner bottom water layer will lead to the development of anoxia in the bottom waters. These conditions include a longer summer season, a warmer, less windy season, lower lake levels, or temperature conditions that lead to the development of a thin bottom water layer. Because Lake Erie is so shallow it naturally has a thin bottom water layer and is therefore more susceptible to anoxia than the other, deeper Great Lakes.

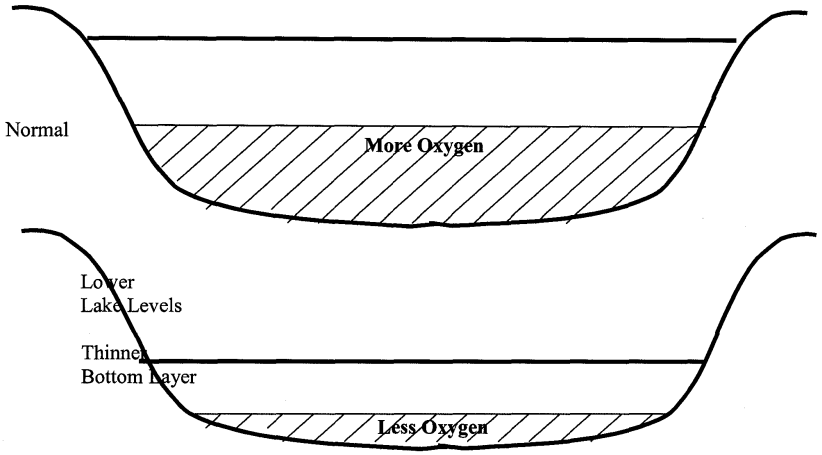
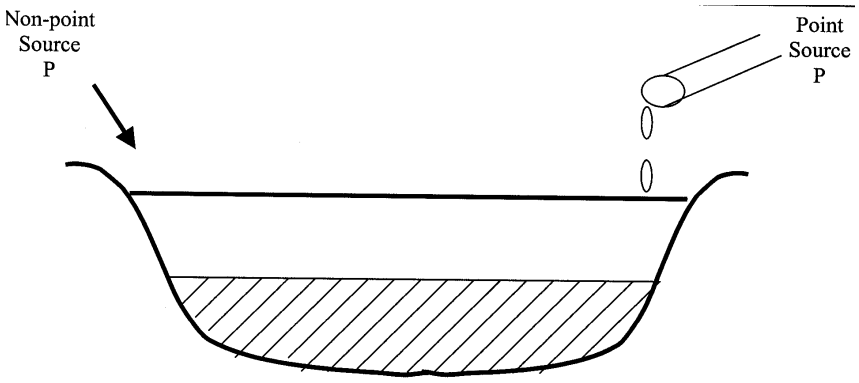


Figure 1. Effects of climate on the development of bottom water anoxia. Anoxia can be facilitated by a longer summer season, a warmer, less windy season, lower lake levels, or a thinner bottom water layer.

A second hypothesis is that the actual P loading to Lake Erie is greater than we are aware of (Figure 2). This could occur because there may be unrecognized P loadings, some point source P loadings may be under-reported, or there may be errors in how some P loadings are calculated, especially from unmonitored non-point source tributaries. If P loadings are actually higher than it is thought, then axoxia may be occurring because the target goal of 11,000 metric tons per year actually has been exceeded.



The third hypothesis is that zebra mussels changed the carbon transfer system of the lake from a pelagic food web to a benthic system (Figure 3). Before zebra mussels, Lake Erie had a pelagic food web where phytoplankton (or at least the larger size fractions) were consumed by zooplankton which were fed on by fish. Since the introduction of the zebra mussel the phytoplankton have been removed from the surface waters of the lake by the filtering action of the zebra mussels. In addition, zebra mussel filtration has facilitated deeper light penetration which has allowed benthic algae and rooted aquatic plants to grow. This has put the majority of the carbon on the bottom of the lake where its decay will consume bottom water oxygen.

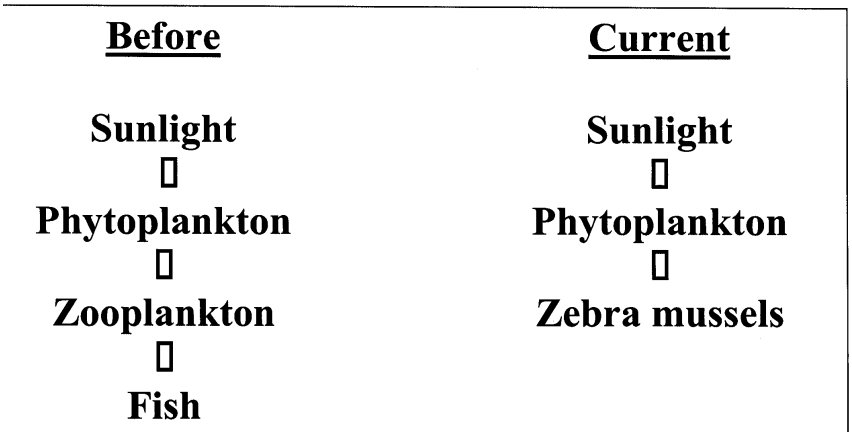


Figure 3. Changes in the food web of Lake Erie caused by the zebra mussel. Before zebra mussels Lake Erie had a pelagic food web where phytoplankton were consumed by zooplankton which were fed on by fish. Since the introduction of the zebra mussel the phytoplankton have been removed from the surface waters of the lake by the filtering action of the zebra mussels. This and deeper light penetration allowing benthic algal production has put the majority of the carbon on the bottom of the lake where its decay will consume bottom water oxygen.

Effects of Anoxia

The development of bottom water anoxia has a number of undesirable consequences. Perhaps the most obvious are massive fish kills. Fish kills result from species that need cold oxygen-rich water to survive but find neither the warm surface water nor the cold anoxic water tolerable. Second, there are often taste and odor (musty smell) problems that occur because of blooms of undesirable algae. Anoxic bottom waters can cause ecosystem changes; for example, mayfly nymphs, a desired food for several fisheries, cannot survive in bottom waters that periodically go anoxic. In fact, their recent return in large numbers in the western basin of Lake Erie has been cited as evidence of the positive response of the lake to reduced phosphorus loadings. Fourth, anoxia and especially eutrophication can lead to blooms of nuisance and toxic algae and the production of water-borne toxins. Anoxia can also lead to increased phosphorus cycling and further eutrophication. Finally, anoxia results in other beneficial use impairments, such as beach closures.

Solutions to Anoxia

Since the cause(s) for the current anoxia are not known, it is premature to propose solutions to solve the problem. The key to determining an appropriate solution to anoxia is to identify the cause(s), understand how the ecosystem responds to the stresses, and then select an appropriate course of action based on potential for success, adverse effects, ease of implementation, and cost. However, if the problem is recurring and expected to continue to remain a problem in the foreseeable future, then the target phosphorus load of 11,000 metric tons per year may need to be revisited. Some other causes, for example a zebra mussel induced problem, will have other possible solution options. Some of these may be untenable or excessively expensive, such as controlling the zebra mussel population by eradication (like lampricide applications for sea lamprey control) or may include natural or induced biological control (such as predation on zebra mussels by round gobies). Climate change causes certainly have significant implications for lake water levels and water diversions. One area of concern is that the continuing introduction of non-indigenous species has generated an ecosystem that is not in equilibrium, and the dynamic nature of the changes are difficult to predict. For example, predation on the zebra mussel by the round goby may lead to control of the zebra mussel population and

reverse some of the adverse effects of the zebra mussel. This means that it will be difficult to understand sufficiently the ecosystem in order to develop an appropriate course of action. Considerably more study on nutrient cycling and on the dynamic nature of the ecosystem will be required.

Current Research

My research grant on the "Trophic Status of Lake Erie" is an initial investigation to begin to develop and understanding of the complex interactions in this highly dynamic ecosystem. Because of the complex nature of the problem, we designed a research project that was substantially more comprehensive than the usual single investigator project. The project includes 27 principal investigators from 18 institutions. The project is primarily field-based to collect samples and data using EPA's RV Lake Guardian and the Canadian Coast Guard Vessel Limnos. The sampling effort includes the measurement of water-related attributes, sediment-related attributes, a zoobenthic inventory and includes studies to derive and extrapolate energy processing and nutrient transfer from zoobenthos though round gobies, and to quantify particle transport processes and nutrient sources among compartments.

Specific objectives include the following:

1) Estimate the historical frequency and extent of episodic anoxia in the bottom waters of the central basin by interpreting geochemical markers (stable isotopes, chemical species of trace materials, ostacode fragments), and other indicators of environmental change derived from sediment cores;

2) A simulated reconstruction of the areal extent, volume, duration, and oxygen depletion of the central basin bottom waters through the 1990's;

3) A lakewide quantitative assessment of dominant zoobenthos populations and distributions, especially dreissenids, oligochaete worms, chironomids, burrowing mayflies, and amphipods;

4) An evaluation of the accuracy and utility of remote-sense technology (side-scan sonar, ROV, videography) in analyzing sediment composition and dreissenid distribution;

5) A bioenergetic model of benthic energy and nutrient transfer through benthivorous round gobies;

6) Estimates of sediment-water boundary exchanges through sublittoral and profundal measurements of sediment oxygen demand, benthic primary production, solute and particle advection induced by physical processes, and bioturbation, and sedimentation rates;

7) Estimates of vertical distribution of nutrients, oxygen, phytopigments and particulate matter;

8) Estimates of epilimnetic and hypolimnetic primary production, respiratory demand, and cycling efficiency using both established and novel approaches;

9) Determination of factors and cofactors (nutrients, trace metals) limiting primary production;

10) Determination of lake-wide phosphorus loading, among-basin transport, and net export;

11) An improved conceptual model of nutrient dynamics that better explains trends in nutrient behavior, primary production, and hypolimnetic oxygen depletion than currently used models.

The field sampling is continuing throughout the summer. To date, sampling trips aboard the RV Lake Guardian occurred in June and July. Since the research efforts have been focussed on data collection, no attempt has been made yet to fully coordinate the data and/or interpret it. However, there have already been some unusual observations. Some of these key, but preliminary findings to date include the following:

- *Anecdotal observations suggest that most of the dressenid mussels were quagga mussels and not zebra mussels and they were mostly dead or in poor condition. A quantitative lake-wide survey is planned for the August cruise. Predation on mussels by another non-indigenous specie, the round goby, may be controlling the dressenid population. Part of this study seeks to evaluate that hypothesis.*
- *A lot of green algae (Spirogyra) were found on the bottom of the lake in the nearshore eastern basin. This is similar to what was found in Saginaw Bay the year after zebra mussels were reported to have cleared the water column. Benthic algal production is probably the result of deeper light penetration and will produce oxygen. It is not known how the amounts of oxygen produced by benthic production compares with oxygen consumed by respiration of bottom algae.*
- *Detroit Water and Sewerage Department (DWSD) loads to the Detroit River from its main outfall were estimated to be 512 MTA in 2001. Along with the 2000 load (517 MTA), this load represents the minimum ever reported and is due to continued effluent flow rates of less than 700 million gallons per day (annual average)*

and declining weighted average phosphorus concentrations. These loads do not include CSOs or bypasses.

- *There is no evidence for iron limitation of phytoplankton growth in the western or central basins.*
- *Phosphorus deficiency was assessed by alkaline phosphatase activities in the central and eastern basins. Higher activities were found in the bottom waters which, along with high concentrations of chlorophyll suggest that there is primary production occurring in the bottom water.*
- *Subjective evaluation of benthic invertebrate populations suggests that densities of mayfly larvae in the western basin are somewhat lower than the previous 2–3 years. Also of interest is the finding of empty shells of the Asian clam Corbicula, another non-indigenous specie, on beaches at 3 locations around the basin.*
- *Measurements of sediment oxygen demand indicate that current rates are near normal for the past decade, with oxygen removal from the bottom water at a rate of about 0.1 ppm/day. However, the data are variable throughout the lake, with higher demands in the central basin than in the western basin and higher demands in shallower water sites than most deeper water sites.*

STATEMENT OF JEFFREY M. REUTTER, DIRECTOR, OHIO SEA GRANT COLLEGE PROGRAM,

F.T. Stone Laboratory, Center for Lake Erie Area Research (CLEAR), and Great Lakes Aquatic Ecosystem Research Consortium, the Ohio State University

"THE DEAD ZONE IN LAKE ERIE: PAST, PRESENT AND FUTURE"

My name is Jeffrey M. Reutter. I have been doing research on Lake Erie, studying this wonderful resource, and teaching about it since 1971. I am the Director of the Ohio Sea Grant College Program (part of NOAA), the F.T. Stone Laboratory (the oldest freshwater biological field station in the country), the Center for Lake Erie Area Research (CLEAR), and the Great Lakes Aquatic Ecosystem Research Consortium (GLAERC). I have held these positions since 1987. I am here today to speak to you about the area of anoxia in the middle of Lake Erie, the so-called "Dead Zone." To do this I need to tell you a little about all of the Great Lakes, how Lake Erie differs from the other Great Lakes, and a little basic limnology so you can understand the problem.

But first, while this is a very complex issue, the take-home message from my testimony is simple. Due in part to changes brought about by invading species, zebra and quagga mussels, I am concerned that we are seeing indications that Lake Erie is heading back to the conditions of the "dead lake" years in the 1960's and early 70's. We must determine if that assessment is accurate, and if accurate, we must identify corrective actions and take them. Finally, we must recognize that Lake Erie may be a model for many other bodies of water in this country, and we must transfer the knowledge we gain from this lake to prevent the same thing from occurring in other locations in this country.

The Great Lakes hold 20 percent of all the freshwater in the world and 95 percent of the freshwater in the United States. The US shoreline of the lakes is longer than the Atlantic Coast, Gulf Coast and Pacific Coast, if we leave out Alaska. Approximately 30 percent of the US population lives around these lakes.

Lake Erie is the southernmost and shallowest of the Great Lakes. As a result, it is also the warmest. It also provides drinking water to 11 million people each day. The other Great Lakes are all in excess of 750 feet deep, and Lake Superior is 1,333 feet deep. The deepest point of Lake Erie is 212 feet in the eastern basin, off Long Point. As a result, Lake Erie is the smallest of the lakes by volume, and Lake Superior is 20 times larger than Lake Erie. The watersheds around the other four Great Lakes are all dominated by forest ecosystems. The watershed around Lake Erie is the home to 14 million people and is dominated by an agricultural and urban ecosystem. As a result Lake Erie receives more sediment and more nutrients than the other Great Lakes. Now, if Lake Erie is the southernmost, shallowest, warmest, and most nutrient enriched of the Lakes, we should expect it to be the most productive of the Great Lakes. It is. In fact, we often produce more fish for human consumption from Lake Erie than from the other four lakes combined.

Lake Erie has gone from being the poster child for pollution problems in this country to being one of the best examples in the world of ecosystem recovery. A little over 30 years ago, 1969, the Cuyahoga River burned and Lake Erie was labeled a dead lake. Nothing could have been further from the truth. In reality the Lake was too alive. We had put too many nutrients into the Lake from sewage and agricultural runoff. These nutrients had allowed too much algae to grow, and that algae,

when it died and sank to the bottom, had used up the dissolved oxygen in the water as the algae was decomposed by bacteria. This sequence is a natural aging process in lakes called eutrophication, but man had accelerated the process by 300 years by putting in too much phosphorus. It is very similar to what we are seeing today in the Gulf of Mexico, but the problem in salt water is nitrogen.

Scientists divide the Lake into three basins based on significant differences in shape and depth. The western basin is the area west of Sandusky and has an average depth on only 24 feet. The eastern basin is the area east of Erie, Pennsylvania and contains the deepest point in the Lake. The western and eastern basins have irregular bottoms with a lot of variation in depth. The central basin is the large area between Sandusky and Erie. The average depth of this basin is between 60 and 80 feet and the bottom is very flat. Unfortunately, it is this shape that causes this basin to be the home of the Dead Zones.

Many of you have probably experienced swimming in a pond and noticed that the deep water was much colder than the surface water. This layering with warm water on top because it is less dense and lighter, and cold water on the bottom because it is heavier, is very common in the Great Lakes. The warm surface layer is called the epilimnion. The cold bottom layer is called the hypolimnion. The line of rapid temperature change between the layers is called the thermocline. In Lake Erie, these layers form in the late spring and break up in the fall when the surface layer cools to the temperature of the bottom layer—normally around September or October.

In Lake Erie, the thermocline usually forms around 45–55 feet. Based on the depths of the three basins, this means the western basin is too shallow to have a thermocline except on rare occasions, the eastern basin will have a thermocline and there will be a lot of water below it in the cold hypolimnion, and the central basin will have a thermocline but there will be a very thin layer of cold water under it in the hypolimnion.

At the time the thermocline forms, there is plenty of dissolved oxygen in the hypolimnion. However, due to its depth, there is often no way to add oxygen to the water in the hypolimnion until the thermocline disappears in the fall. Therefore, throughout the summer the oxygen that was present when the thermocline formed is used by organisms living in this area, including bacteria, which are decomposing algae as it dies and sinks to the bottom. If large amounts of algae are dieing and sinking, then large amounts of oxygen will be required for the decomposition process. It should then seem logical that if we could reduce the amount of algae, we could reduce the amount of oxygen that would be required to decompose the algae.

Because the western basin seldom has a thermocline, this is not a problem there. And, because the eastern basin is so deep, there is a large reservoir of oxygen in the hypolimnion—enough to last through the summer until the thermocline disappears in the fall. The central basin, however, does not have a large reservoir of water or oxygen in the hypolimnion because the basin is not deep enough. As a result, loss of all the oxygen, or anoxia, can be a serious problem in the bottom waters of the central basin. Areas of anoxia were first observed as early as 1930, and by the 1960's and 1970's, as much as 90 percent or the hypolimnion in the central basin was becoming anoxic each year. This is why Lake Erie was labeled a "dead lake." When an area becomes anoxic, nothing but anaerobic bacteria can live there. Also, this water creates severe taste and odor problems if it is drawn in by water treatment plants servicing the population surrounding the Lake.

To reduce the amount of algae in the Lake, we needed to reduce the amount of the limiting nutrient. By "limiting nutrient," I mean the essential nutrient that is in the shortest supply. Without this nutrient algae cannot grow and reproduce. In freshwater this nutrient is phosphorus. In 1969, we were loading about 29,000 metric tons of phosphorus into Lake Erie each year. Our models told us that in order to keep dissolved oxygen in the central basin, we needed to reduce the annual loading of phosphorus to 11,000 metric tons. This was accomplished and the recovery of the Lake has been truly remarkable. The walleye harvest from the Ohio waters jumped from 112,000 in 1976 to 5 million in 1988 and the value of this fishery exceeds the value of the lobster fishery in the Gulf of Maine. Small businesses associated with charter fishing increased from 34 in 1975 to about 900 today, and Lake Erie became the "Walleye Capital of the World."

Then on 15 October 1988, we documented the first zebra mussel in Lake Erie. Recognizing the significance of this discovery, Ohio Sea Grant initiated a research project on 15 November to document the expansion of the mussels. One year later, the densities in the western basin had reached 30,000 per square meter. Their impact was so great that in 1993 I addressed the International Joint Commission and asked them to create a special task force to try to understand the huge changes that were occurring in Lake Erie. I was asked to be US Co-Chair of the Lake Erie Task

Force for the International Joint Commission from 1994–1997 as we developed models to better understand the impact of the zebra mussel on the ecosystem of the Lake.

In 1998 I formed the Phosphorus Group, a group of about 50 scientists from the US and Canada to discuss phosphorus levels to determine if they might have gotten too low and were harming the fishery—at that point the walleye fishery had been reduced by about 60 percent and the smelt population had been decimated. This group concluded that based on changes in the system caused by zebra mussels, adding more phosphorus would create more zebra mussels and more inedible, blue-green algae.

At the end of 1998, Drs. Jan Ciborowski (University of Windsor), Murray Charlton (National Water Research Institute of Canada), Russ Kreis (US EPA) and I formed the Lake Erie at the Millennium Program to continue to lead discussions and focus attention on the huge changes that were occurring in Lake Erie. We have documented a number of new invaders to the Lake, including the round goby, and have observed the gradual transition from zebra mussels to quagga mussels.

In the mid–1990's, US EPA's Great Lakes National Program Office (GLNPO) observed an increase in phosphorus levels in Lake Erie and the increasing trend has continued. They also observed areas of anoxia in the central basin that showed indications of growth. In 1996 we observed a bloom of blue-green algae in the western basin—an indication that phosphorus levels were high. In 2001 we saw more indications that dissolved oxygen levels were critically low, and we observed that mayfly larvae had been eradicated from several regions—a clear indication that oxygen had been eliminated. We also observed reduced water transparency over the artificial reefs we had worked with the city of Cleveland to produce from old Brown's Stadium—another indication of an anoxic hypolimnion.

The above information was shared with the GLNPO and they asked me to bring together a group of Lake Erie experts for a meeting in their Chicago offices on 13 December 2001 to discuss the problems we were observing in Lake Erie and strategize about solutions. As a result of this meeting, GLNPO issued a call for research proposals in January 2002 and they are currently funding a one-year project lead by Dr. Gerry Matisoff, Case Western Reserve University, and the four scientists mentioned above from the Millennium Program, to attempt to better understand the dissolved oxygen problem in Lake Erie.

We believe the oxygen problem is real and that it is growing. We believe it is caused by excess phosphorus, but we also believe zebra mussels and quagga mussels are having an impact because they appear to alter the way phosphorus cycles through the system. I also wish we had better loading estimates for phosphorus, because it is possible that loads are increasing.

Finally, I must mention global warming and climate change because that is also exacerbating the dead zone problem in Lake Erie. When I first started working on this lake, water levels were increasing and we often said, "dilution is the solution to water pollution." This is no longer the case. Since 1997 the water level has gone down by 3–4 feet. We are currently near the long-term average water level for Lake Erie, but we are lower than we have been for over 30 years. This is important because this reduction comes primarily from the hypolimnion (the cold bottom layer). Therefore, as the water level goes down, the volume or thickness of the hypolimnion is reduced, the oxygen reservoir in the hypolimnion is reduced, and, as a result, the area of anoxia will increase and last longer each year. This will hurt fish populations, the charter and commercial fisheries (Lake Erie supports the largest freshwater commercial fishery in the world), our boating and tourism industries, and public health.

As for my predictions for this year, I hope I am wrong, but I fear that this could be a very bad year. We had a very wet spring. This means we probably received large loadings of phosphorus from agricultural runoff and from sewage treatment plants—many of our systems still have combined storm and sanitary sewers allowing untreated sewage and the nutrients it carries to enter the Lake every time we have a storm. Water levels have remained very low so the hypolimnion will not have a large reservoir of oxygen. Together these things mean we could experience a very large dead zone.

We need your support to rapidly do the necessary research to confirm our beliefs about this situation. The current GLNPO study should be expanded and continued for at least two more years. We also need to accurately measure phosphorus loading to all of the Great Lakes on a continuing basis. We need research to determine how best to reduce phosphorus loading. We need to prevent future introductions of aquatic nuisance species. We need to determine if there is a link between the dead zone and the botulism problems we are observing in the eastern basin. We need to do the best we can to solve these problems with our current technologies, but we

also need support for research on new technologies to: address the oxygen problem, control zebra mussels and other aquatic nuisance species, remove nutrients at sewage treatment plants, reduce agricultural runoff, etc.

I believe Lake Erie is the sentinel and we should develop models to extrapolate our results to other bodies of water that contain mussels so they can be prepared for the problem and take preventative action before it occurs.

RESPONSES OF JEFFREY M. REUTTER TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Dr. Reutter, how is the round goby impacting Lake Erie?

Response. The round goby invaded Lake Erie in the early 1990's. Whereas zebra mussels expanded primarily from west to east, gobies did the opposite. By the mid–1990's, gobies were the most abundant nearshore, bottom fish in northeastern Ohio (numbers in the range of 20/square meter were not uncommon), whereas they were rare in 1996 in the island region of the western basin. By the early 2000's, densities of gobies on the western basin Reefs ranged up to 50/square meter.

In the central and eastern basins of the Lake they appear to be forcing the native mottled sculpin (a small fish) out.

Round gobies are eating zebra and quagga mussels. This sounds good, but there is a serious problem. Zebra mussels have a fat content 10 times the level of native clams. This allows them to concentrate (bioaccumulate) fat-soluble contaminants like PCBs at 10 times the level of native clams. They pass this contaminant burden on to the round gobies when they are eaten. Round gobies are in turn eaten by smallmouth bass, a prized sport species, and they pass the contaminant burden on to the bass when they are eaten. Thus, we have a new pathway to adversely impact human health by increasing exposure to toxic substances. All of these contaminant transfers have been identified and confirmed by research we have supported.

Round gobies do not have an air bladder. Therefore, when they stop swimming they sink to the bottom. Consequently, their normal habitat has them resting on the bottom and feeding in that location. They like to eat fish eggs. Research supported by Ohio Sea Grant and the Ohio Division of Wildlife has confirmed that they do invade smallmouth bass nests and steal the eggs when the bass parents are removed from, or vacate, the nests for even very short periods of time. This may adversely impact bass populations.

Finally, round gobies are a real nuisance to the sport fishing community, as they steal bait and are difficult to keep off the line when the angler is targeting other species.

Question 2. Dr. Reutter, what can be done to more accurately monitor and measure phosphorus loading into the Great Lakes?

Response. This is a great question and an important issue for at this point our estimates of phosphorus loading are not accurate enough. They must be improved if we decide that phosphorus loads require further reductions. A number of new programs (the buffer initiative, for example) have been initiated in the past few years, but the impact of these programs is seldom, if ever, measured.

Clearly, phosphorus levels have increased since 1995. We believe that zebra and quagga mussels are playing a role in that increase. This recycling of nutrients within the system is extremely important. Research and monitoring is needed to measure this recycling in addition to the standard external loading.

In the 1970's we had pretty good estimates of phosphorus loading, but it required cooperation between the States, provinces, and the Federal Government to get the estimates. I believe many people felt that this old phosphorus problem was solved, so over the years the commitment on the part of all involved waned—States and provinces chose to put their resources in other areas.

To re-establish the monitoring network, I would suggest the establishment of a Nutrient Loading Task Force within the International Joint Commission with representation from US EPA and Environment Canada. The Task Force would be charged to rapidly assess the accuracy of our current loading estimates and to make recommendations to the governments on how to increase the accuracy.

While it is very important for us to be able to accurately measure phosphorus loading, we will need to review and extensively modify our old phosphorus models. Now that we have zebra and quagga mussels, it is likely that our old phosphorus models no longer work. Therefore, the old target for allowable phosphorus loading (11,000 metric tons per year) may no longer be accurate.

Question 3. Dr. Reutter, what efforts are underway to prevent the introduction of aquatic nuisance species into the Great Lakes? What more can be done to protect the Great Lakes from future introductions of aquatic nuisance species?

Response. The first ANS act was passed in 1990. Since then we have averaged about one new invader each year. Therefore, we have not closed the door. A new act is currently being developed. However, no existing technology is 100 percent effective. Therefore, we need additional support for research to develop new and better technologies. A current technology that is 99 percent effective, could still be allowing millions of viruses or bacteria to enter the lakes from one vessel. We clearly need a technology that is 100 percent effective. Without such a technology, we must either greatly reduce shipping and or shipping volumes by eliminating any discharge of ballast water, or we must accept the continued risk of ANS introductions and continue to try to minimize that risk.

Question 4. Dr. Reutter, given all the Federal, State, local, international, and nonprofit entities involved in research and efforts to restore and protect the Great Lakes, how can all these efforts be better coordinated and funding sources be stretched farther?

Response. I have to admit that there are times I wish we could throw out all of the current organizations and start over—not likely to happen. We are most likely to continue with a wide variety of somewhat overlapping agencies. While this can be quite confusing, particularly to someone unfamiliar with the system, regional efforts to communicate and collaborate are quite effective. In Lake Erie, I can assure you that there is no duplication of effort.

Addressing the "dead zone" issue—developing a plan to solve it and implementing the plan—will take significantly increased funding. I hope the Federal Government can provide that money. With regard to where it should go, I strongly recommend US EPA and Ohio Sea Grant (through NOAA). I make this recommendation because these are the only two organizations (other than the Lake Erie Protection Fund) that have been funding research on this critical issue and these are the two groups with the most expertise and capabilities to address the problem. I am also confident that dollars invested in these groups will actually reach the problem (I can guarantee it for Ohio Sea Grant). US EPA and Ohio Sea Grant recognized this problem early, are familiar with it, and have collaborated and cooperated on projects to address it. Furthermore, both groups use a peer review strategy to be sure that only the best research and monitoring efforts are funded.